ARTIFICIAL ANÆSTHESIA

AND

ANÆSTHETICS.

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PREFACE.

This manual on artificial anæsthesia and anæsthetics, is necessarily of limited size yet is intended to be complete in detail so far as important facts are concerned. It is a *résumé* of the uses, abuses, and dangers of each anæsthetic substance, based, not alone upon personal preference, but upon a careful consideration of the great mass of testimony, clinical and experimental, adduced by investigators both at home and abroad.

If we have succeeded in making the book a thoroughly practical guide to the student of artificial anæsthesia and anæsthetics, the labor involved in its preparation is more than compensated. It is true, as Dr. Dudley Buxton says in his valuable work, "Anæsthetics," (London, 1888), that "the medical man cannot acquire more than a mere rudimentary knowledge of anæsthetizing from any book, but he may obtain undoubted service therefrom, in enabling him to appreciate the dangers incident to, the caution necessary in, anæsthetizing, and be enabled to grasp the *rationale* of the various methods of procedure in the administration of anæsthetics."

We desire to express our obligations to the publisher, Mr. George S. Davis, for the attractive style in which the work has been issued.

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CHAPTER I.

HISTORICAL.

The term "anæsthesia" was introduced into medical nomenclature in 1847, by the late Sir James Y. Simpson. As its derivation implies, it means the state of being without sensation. To produce this condition artificially, substances known as anæsthetics are employed: we therefore define an anæsthetic as any agent which possesses the property of abolishing sensation.

The use, in medicine, of anæsthesia as produced by anæsthetics, is to alleviate pain, to render the diagnosis of an obscure condition more easy, or to relax spasm, as in tetanus, etc.

The idea of annulling pain in surgical operations is a very old one. Compression of the nerves and blood-vessels, and the inhalation of the vapor of mixtures containing carbonic anhydride, were practised at an early date. Pliny and Dioscorides speak of a wine of the root of the mandragora, which was used to induce sleep. Lucius Apuleius, who lived about A. D. 160, writes, that "if a man has to have a limb mutilated, sawn, or burnt, he may take half an ounce of this wine, and whilst he sleeps, the member may be cut off without pain or sense." The Assyrians and the ancient Chinese seem to have employed various drugs with a view of relieving pain caused by wounds

or by such rough surgery as was practised among them. Cannabis indica, opium, and carbonic oxide were advocated to attain this object.

Previous to the present century, but little advance was made in the use of anæsthetic drugs, most surgeons being contented to place their patients deeply under the influence of opium, with recourse in certain cases to the effects of intoxication from alcohol. Refrigeration of the tissues with freezing-mixtures, and the phenomena of hypnotism, were occasionally employed for the relief of pain. James Moore, in 1784, proposed to effect anæsthesia in surgical operations by compression of the principal nerves of the affected limb. The illustrious John Hunter actually took advantage of this plan, and amputated a leg at St. George's Hospital, London, after firmly compressing the crural and sciatic nerves. Mesmerism, as suggested by Mesmer and his followers, has been resorted to in some few surgical cases. Dr. Esdaile employed this method somewhat widely in India, according to his own statements, with success; but it has seldom been resorted to, either in this country or abroad, as a means of inducing surgical anæsthesia.

The tardy progress thus far noted toward the discovery of a really satisfactory method of producing artificial anæsthesia was no doubt due to the rudimentary condition of chemical science. During the early part of the latter half of the last century,

Scheele, Hales, Lavoisier, Priestley, and Cavendish gave a powerful impulse to the progress of science in this direction, by their discoveries among the gases. Oxygen, nitrogen, nitric oxide, etc., were prepared and closely studied, and in 1772 Priestley added nitrous oxide gas to the list. Pneumatic chemistry, till then unknown, became the absorbing theme among chemists; while physicians sought to bring these newly-discovered gases into the service of medicine, in the hope that among them might be found something of value in the treatment of pulmonary disease. In the year 1799 (April 9th), Sir Humphry Davy, then laboratory assistant of Dr. Beddoes, in the Pneumatic Institution at Clifton, near Bristol, discovered the exhilarating properties of nitrous oxide gas. Having inhaled it himself to relieve the pain of a coming wisdom-tooth, and noting its anæsthetic properties, he records his experience, with the following comment: "As nitrous oxide, in its extensive operation, seems capable of destroying physical pain, it may probably be used with advantage in surgical operations in which no great effusion of blood takes place." Further observation will be found in his work entitled "Researches, Chemical and Philosophical, chiefly concerning Nitrous Oxide." The above-quoted paragraph, though widely circulated, seems to have excited but little professional interest; and it was not until a Hartford dentist, Horace Wells, turned his attention to the subject in 1844, that any

practical or lasting result seems to have been produced. His courage in trying the gas himself by way of experiment in order to have a tooth extracted, the successful issue of the experiment, and his utterance on recovering from the influence of the gas,—"A new era in tooth-pulling!"—need no comment here. Unfortunately, Dr. Wells met with several trying disappointments, owing to the fact that the gas sometimes failed to produce the desired effect. His chagrin at these failures became so great that he ceased to interest himself further in the subject. His mortification, in fact, was so intense that his mind became affected, and he died by his own hand in January, 1848,—a sad ending for one who should have been honored and rewarded by his fellow-men for a discovery from which dates the commencement of modern painless surgery.

In 1846 (November 30), W. T. G. Morton, a dentist in the city of Boston, who had seen some of the attempts of Wells, tried an agent which had often been used in the lecture-room as a substitute for nitrous oxide to produce the ordinary exhilarating effects of that gas. This substance was sulphuric ether, with which drug, as an anæsthetic, Morton was entirely successful. Other experiments with ether had been suggested to Morton by Dr. Chas. T. Jackson, a noted chemist. The first patient upon whom Dr. Morton operated, after trying the effects of the remedy upon himself and inducing an artificial sleep of

some eight minutes' duration, was a man named Eben Frost, who applied for the relief of an aching tooth and was successfully kept under the influence of ether during the time of its extraction. It was at once perceived that a wider range of utility than was afforded by the practice of dentistry was open to the use of this agent, and on the 16th of October, 1846, Morton was invited to administer the remedy to a patient of Dr. J. C. Warren, at the Massachusetts General Hospital, from whom a vascular tumor of the neck was to be removed. The success attending its employment in this case led to a repetition of the experiment again and again, until a number of capital operations had been performed with the most satisfactory results.

The news of this great discovery soon spread abroad, and in England the first administration of ether took place in Gower Street, London, close to the University College Hospital, when a Mr. Robertson, a dentist, removed some teeth from a patient under its influence.

The enthusiasm which naturally followed the brilliant discovery of Morton, and the rapid spread of the use of ether, directed considerable attention to the subject of anæsthetics, and led to many experiments in other channels by careful observers, in the hope of discovering some agent even more efficacious than ether as a producer of artificial anæsthesia. Among others, Dr. (afterwards Sir) James Y. Simpson, of Edinburgh, was thus aroused, the result of his ex-

periments and research being to establish the anæsthetic power of chloroform, in November, 1847.

The agreeable properties of chloroform as an anæsthetic, led to its speedy adoption in preference to ether, not only in Great Britain but almost throughout the world. In America, however, many surgeons wisely clung to the older and more tried remedy, ether. We say wisely, for though chloroform was believed to be a "safe anæsthetic" it had not as yet stood the test of time and experience. Unfortunately, this belief in the safety of chloroform was doomed to be shaken, when on January 28, 1848, a death from the drug was reported at a place near Newcastle-on-Tyne. This accident was soon followed by the reports of other deaths, and finally led to the researches of E. Snow, published in his experimental papers on "Narcotic Vapors," in 1848. Snow's experiments made him regard chloroform as dangerous, though pleasant, a conclusion that has been reached by the large majority, at least of American surgeons.

To overcome the objection to the use of chloroform, various apparatus have been devised and various mixtures of chloroform, ether, and alcohol suggested, but to these we shall have occasion to refer later.

In a somewhat cursory manner, we have covered the historical ground of anæsthetics and artificial anæsthesia. The extant literature on this portion of the subject would constitute a library of itself; we

have therefore satisfied ourselves with a condensed statement of facts, such as the scope of this work seemed to justify, avoiding the many controversial points which have made the history of anæsthetics a veritable literary battle-field.

For a more exhaustive article upon the history of anæsthetics, the reader is referred to the very interesting work, "Anæsthetics, Ancient and Modern," by George Foy, F. R. C. S., London, 1889.

CHAPTER II.

PREPARATION OF A PATIENT FOR ARTIFICIAL ANÆSTHESIA, WITH THE METHODS OF ADMINISTERING ANÆSTHETICS.

The state of perfect anæsthesia is one of the most grave conditions of life, bordering so closely on the boundary-line of death that it is wonderful how near that line can be approached under the use of the anæsthetizing agent and yet be so rarely passed. Such being the case, it behooves the anæsthetizer to remember that familiarity with the use of anæsthetics should not bring with it a contempt for the dangers involved; on the contrary, each successive case, during the period of anæsthesia, should be watched with the utmost care and anxiety; only then is the physician giving the patient the best chance for life and fulfilling a duty to himself and to his fellow-being which his position demands.

Bearing in mind, then, the state of a patient during the administration and continuance of an anæsthetic, it will be perceived that the preparation of an individual for the ordeal must play an important part as a factor in the result obtained.

In each case, therefore, advantage should be taken of every assistance that in the slightest degree will aid nature in withstanding the strain to which she is subjected.

An examination of the physical condition and of the urine of the patient having resulted in a favorable decision as to the propriety of resorting to artificial anæsthesia, the next point for consideration is the selection of a suitable hour—a matter of by no means minor moment. True, it is not of vital importance in anæsthetizing the robust, but in the case of a weakly or highly neurotic subject it becomes a point for careful consideration. Individuals are more liable to after-effects of an unpleasant character when their bodily condition is one of nervous exhaustion and lowered vitality. It is therefore unadvisable, unless force of circumstance compels, to give an anæsthetic after a prolonged fast,—for instance, in the early morning before food has been taken. Similarly, it is unwise to select an advanced hour of the day, when the body is exhausted with suffering or work. Further, an anæsthetic should not be given within three hours after an ordinary meal, unless an emergency indicates otherwise. This precaution is especially needful when ether is administered, since vomiting is liable to be excited when the stomach is full. Nothing is more disagreeable and annoying to the surgeon and attendants than to have a quantity of undigested food pouring from the mouth of a half-conscious and helpless individual at such a time. Such an accident under these conditions is attended with considerable danger: some cases have been recorded of death from suffocation during the induction of anæsthesia, by

solids being drawn into the trachea during the act of vomiting, and not infrequently the pharynx and mouth are blocked by the ejecta. In cases of anchylosis of the jaws such accumulation is serious, and will require prompt measures for its relief.

The best time for an operation of selection is either in the morning or in the early afternoon, as these are the periods of greatest vital activity.

The diet of a patient previous to taking an anæsthetic is very important; it should consist of a meal of soft and easily-digested food, which should be taken three hours before the surgeon is expected to arrive; for example, a cup of milk, tea or coffee, some toast, a poached egg, etc., varying with the time of day and the taste of the patient.

In some cases, one or two tablespoonfuls of good brandy or whiskey administered half an hour before anæsthesia will do good; but alcoholic stimulation is not a necessary or wise routine treatment.

A recommendation worthy of note is the favorable modification of the action of anæsthetics by the use of morphine hypodermatically, of which drug from one-sixth to one-third of a grain should be given to an adult at least *forty minutes* before beginning the administration; otherwise, if an operation is to be practised immediately, according to an extensive series of observations made by MM. Rigaud and Sanazin at the hospital of Strasbourg, an injection of morphine will augment the period of excitement, and

if the dose be tolerably large, accidents on the part of respiration may occur.

The administration of an opiate, in the manner directed, is asserted to act happily in reducing the stage of excitement and the tendency to vomiting; also it is said to promote sleep, and to lessen by one-half to one-third the amount of the agent necessary to induce anæsthesia. This plan of modifying the anæsthetic process by hypodermatic injections of narcotics was first practised by Nussbaum, the eminent Munich surgeon, who published a paper on the subject in the *Bavarian Medical Intelligencer* for October, 1863. Bernard, the noted French physiologist, also has received credit for this discovery, and claims to have made known his experiments upon animals during the same week in which Nussbaum made his first observations on the human subject; but, as he gives the year as 1864,* it is more than probable that he was mistaken.

We are aware that a wide difference of opinion exists as to the beneficial effects of opium in combination with either chloroform or ether, used as above mentioned. Among its opponents may be mentioned the late Dr. Albert H. Smith, of Philadelphia, and Dr. Laurence Turnbull, the author of a work entitled "Artificial Anæsthesia."† Kappeler, from an experi-

* Leçons sur les anesthésiques et sur l'asphyxie, par M. Claude Bernard, Paris, 1875, pp. 225–26.

† Third ed., pp. 496–98.

ence of twenty-five cases, gives an opinion decidedly opposed to the combined use of ether and morphine. Most of the objectors to the practice of mixed anæsthesia admit that the conjoined employment of morphine and chloroform is open to less objection than the same use of morphine and ether.

The objections urged against the use of a narcotic in these cases are, that in combination with ether opium is apt to produce a great tendency towards respiratory failure; and, in the case of its administration before employing chloroform, that it is liable to provoke undue excitement and emesis.*

We are inclined to take an intermediate view as to the value of an opiate used previous to the administration of an anæsthetic.

When an operation is to be a protracted and severe one, an opiate in combination with one-hundredth or one-seventy-fifth of a grain of atropine, hypodermatically given (which latter drug acts happily as a reliable cardiac respiratory stimulant), does good and lessens the amount of the anæsthetic required. Such a combination of atropine with a narcotic is valuable in cases where great dread of the operation exists, the mental shock incident to the emotional state produced, being thereby soothed and tranquillized and the patient enabled to pass quietly into unconsciousness without running the risks otherwise encountered.

*Turnbull, *loc. cit.*

According to Koenig, in more than seven thousand cases treated with hypodermatic injections of morphine before inhalations of chloroform, not a single death was reported. In his experience the use of the narcotic was especially serviceable in the case of professional drunkards and chronic tipplers, the introduction of the drug considerably shortening the period of excitement under chloroform.

It is our opinion that whenever a hypodermatic injection of morphine precedes an anæsthetic, there is no question that atropine should be added. Its power as a cardiac respiratory stimulant has been long recognized,† and its value as a means of lessening the danger of respiratory and cardiac syncope under chloroform duly appreciated.‡ As a *preventive* of accident, atropine is undoubtedly far more reliable than it is as a means of rescue when danger has occurred.

For a very able essay upon the subject of the modification of the anæsthetic process by the hypodermatic injection of narcotics, we refer the reader to an article by Dr. J. C. Reeve, of Dayton, Ohio, in the *American Journal of the Medical Sciences* for April, 1876, p. 374.

Among the other drugs which favorably modify the influence of anæsthetic agents and render their

† Harley, The Old Vegetable Neurotics, 1869.

‡ Bartholow, prize essay, Trans. Amer. Med. Assoc., 1869.

administration safer may be mentioned strychnine, which, in Dr. Willard's experience, does good in doses of $\frac{1}{120}$ of a grain hypodermatically administered. Dr. H. C. Wood recommends chloral, administered shortly before etherization, which he asserts causes the first stages of the ether-narcosis to be much quieter than usual, and also prolongs the anæsthetic effect of the drug.

When an operation is one of election, and time permits, the bowels should be thoroughly moved by means of some mild cathartic, best administered the night previous, followed by an injection in the morning.

No patient should be anæsthetized without an examination of the mouth to see that it contains no artificial teeth, tobacco, or other foreign body. It is also a good plan to see that the bladder is empty. Perfect quietude should be enjoined on all around the patient, as noises or even loud talking interfere with the perfect and rapid action of the anæsthetic. Nothing like a tight band or garment should be allowed to impede the free action of the throat, chest, or abdomen, or to interfere with the muscles of respiration. All sources of excitement to the patient should be avoided, such as the sight of the instruments, the presence of too many spectators, etc., since they tend to induce shock.

The temperature of a room in which ether or chloroform is to be used should not be below 70° F.;

when the trachea is opened, 85° F.; when the abdomen, 75° to 80° F. The apartment should be a large and airy one.

Appliances should be at hand for ready use in case of an emergency requiring resuscitation or of any other accident likely to occur during the administration, the principal articles being a battery, a mouth-gag, a pair of catch-forceps with which to draw the tongue forcibly forward if necessary, a tongue-depressor, ammonia (both the aromatic spirit and the aqua), brandy or whiskey, tincture of digitalis, strychnine, and a solution of atropine, together with a hypodermatic syringe. Accidents are so common, that it is unwise for any physician to anæsthetize even a child without a competent assistant.

Having thus carefully prepared everything for the ordeal through which the patient is to pass, we are prepared to consider the proper methods of the

ADMINISTRATION OF ANÆSTHETICS.

For our present purpose it will suffice to consider the ordinary employment of ether or chloroform, leaving the consideration of the administration of nitrous oxide and other less-used anæsthetic substances for the chapters which particularly treat of their use.

The position of a patient about to be anæsthetized, for all ordinary operations, is the recumbent one, which diminishes the risk of syncope by favoring

the access of blood to the brain. Sudden shifting of position should be avoided, especially from the supine position to the vertical, as an abrupt change of this character might easily occasion syncope. If the patient struggles and resists inhalation, he should be gently but resolutely restrained. A soothing word at this time does much toward quieting such resistance.

The position of the etherizer should be either at the head of the patient or at his right side, where he can conveniently hold the inhaling apparatus with one hand, while with the other he can ascertain the condition of the pulse.

The best ether inhaler, for ordinary purposes, is a napkin or towel, twisted into a cone, and stiffened by means of a sheath of paper or leather, the cone being left open at the top, which opening is filled with a sponge or a piece of absorbent cotton. At first the cone should be only slightly saturated with ether, and should be gradually brought toward the face, in a manner calculated to avoid giving unnecessary alarm to the patient. By this method, the feeling of suffocation and of instinctive apprehension, which otherwise might lead to considerable resistance on the part of the patient, may be in great part avoided. A few encouraging words at this moment are often needed to reassure the patient; he should be requested to "blow out;" for, as Prof. John Ashhurst remarks,*

* Principles and Practice of Surgery, 4th ed., p. 78.

"the vapor of ether is so penetrating and irritating to the throat that it is very difficult voluntarily to draw it in by deep inhalation; but it is perfectly easy to blow into the cone, and, as a full expiration is inevitably followed by a deep inspiration, the surgeon's purpose is thus most readily accomplished; contrary to what happens when the patient is directed, as is usually the case, to 'draw in his breath.'"

The induction of anæsthesia should be slow. From five to ten minutes are usually required for the completion of this process in the male adult; females and children yield more rapidly. As far as possible, it is desirable to maintain a uniform rate of inhalation and a uniform saturation of the air that is passed into the lungs; this can be approximately done by adding ether steadily, drop by drop.

The condition of complete anæsthesia is to be recognized by the relaxation of the muscular system. A favorite method of ascertaining this fact is to raise an arm of the patient and then allow it to drop by the side; the countenance becomes tranquil and the eyes are closed, the patient lying quietly as if in a deep sleep; the movements of respiration are regular and rather less frequent than normal; inspiration is deep, and may be accompanied by snoring; the pulse becomes full and soft, and is not accelerated; it may be even slower than at the beginning of inhalation. Insensibility of the conjunctiva is a good test of the complete production of artificial anæsthesia, but is

not so reliable as the absence of muscular rigidity. Rude testing of the conjunctival reflex may develop conjunctivitis. Boncour, of France, thinks that thorough contraction of the pupils, continuing even when the skin is pinched or the cornea is lightly touched, is a surer sign of complete anæsthesia than mere insensibility of the cornea.

When complete anæsthesia has been thus determined, the anæsthetic state should be carefully maintained by the uninterrupted administration of small quantities of the ether vapor.

The accidents of anæsthesia, as well as the treatment of patients after the administration of an anæsthetic, will be considered in the chapters treating of the special anæsthetic agent.

CHAPTER III.

GENERAL ANÆSTHETICS.

SULPHURIC ETHER.

Ether, or Ethyl Ether, $(C_2H_5)_2O$, was discovered in the year 1540, by Valerius Cordius, who gave to the substance the name of *oleum vitrioli dulce*. Frobenius changed this name to *ether* in the year 1730.

Chemical and Physical Properties.—Ether is a colorless, translucent, highly volatile liquid, having a peculiar, exhilarating odor, and a burning taste which is followed by a sensation of cold and numbness. It is very inflammable, and its vapor, when mixed with air, detonates with great violence if brought in contact with flame: hence it is important to avoid the proximity of lighted gas-jets, candles, etc., and as its vapor has a considerable tension at ordinary temperatures, diffusing quickly to some distance, great danger is incurred in pouring it out of one receptacle into another in such surroundings.

Ether, if kept in a hot place and in an imperfectly-stoppered bottle, is liable to undergo oxidation, acetic acid and other products being formed, which make it unfit for inhalation.

General Properties and Uses.—Ether is a powerful diffusible stimulant, possessed also of expectorant, antispasmodic, and narcotic properties; it is the safest

known agent for the production of prolonged narcosis. It is employed alike for its power of producing local anæsthesia, which it does by causing rapid abstraction of heat so as to benumb the cutaneous endings of the sensory nerves, and for its power of inducing complete unconsciousness to pain (general anæsthesia) through its action on the cerebro-spinal centres.

For prolonged and capital operations, the safest known systemic anæsthetic is, without doubt, ether; it is superior to nitrous oxide, because it may be inhaled for hours without the danger to life which is involved in the long-continued use of the latter drug; it is less dangerous than chloroform, because its vapor, when undiluted, is practically safe, whereas chloroform, unless kept below four per cent. of the air breathed, seriously imperils life.

There are, however, cases in which ether is contra-indicated. These may be narrowed down to acute inflammatory affections of the respiratory tract and all conditions of laryngeal and tracheal stenosis; protracted operations about the mouth, jaws, nose, or pharynx; when the thermo-cautery is to be used on the head or its vicinity, or when an operation is to be done in a small room near an open fire; brain tumors and degenerations; thoracic tumors or aneurism.

In old persons, whose arteries are presumably brittle, or in cases of extensive renal disease, the drug should be given with the utmost caution. As has

been already stated, it is of the greatest importance when an anæsthetic is to be administered, that the condition of the kidneys be ascertained by an examination of the urine. In extensive disease of these organs, the blood being loaded with urea, the use of an anæsthetic is liable to produce convulsions, coma, and death. Dr. W. F. Norris has recorded several cases of death supervening from ether after operations for cataract. In these cases no organic lesion was found at the autopsy, except advanced Bright's disease. Somewhat similar cases have been reported by Emmet, Hunt, and Montgomery, verified by post-mortem examination.*

The Physiological Action of Ether.—When inhaled, ether produces a burning and choking sensation,—in some, almost suffocation,—due to the local impression of the irritant vapor. The first indications of its systemic action are a sense of exhilaration and a lightness of the head, associated with a roaring or buzzing in the ears. These are soon succeeded by a feeling of the immediate surroundings being afar off, and this soon fades into semi-unconsciousness, with visions and illusions. These are of various characters, and are often accompanied by a species of delirium. In the graphic language of Dr. Wood, some patients weep, others laugh, some shout, some pray, some roar, and some become pugnacious. In rare instances the

* Turnbull, *loc. cit.*

dreams become erotic, and cases are on record in which there were distinct evidences of the occurrence of a complete venereal orgasm. No female should ever be anæsthetized except in the presence of a third person. In this stage the patient, in most cases, may be more or less perfectly aroused. This primary stage of anæsthesia can be made use of for minor surgical procedures, such as opening abscesses, and the like.

In a brief article, published in the *Philadelphia Medical Times* in 1872, Dr. John H. Packard referred to the advantages of this stage of ether-anæsthesia for the performance of operations requiring but a short time. Subsequent experience has convinced him of the value of the idea.

In the *American Journal of the Medical Sciences* for July, 1877, Dr. Packard writes as follows: "If, when a patient begins to inhale the ether vapor, he be told to hold up his hand, and the direction be repeated as often as necessary, for a little while he will obey, but soon there will be a failure of voluntary power, and the hand will drop. At this instant there begins a very brief period—less than a minute—of total insensibility. If the inhalation be now suspended, consciousness will return at once, and the patient will come to himself without headache, nausea, or any other of the disagreeable effects so commonly experienced after the prolonged administration of the anæsthetic. During the brief period of anæs-

thesia—the 'first insensibility,' as I have called it—any operation may be performed as painlessly as if the inhalation had been carried to its fullest extent."

Dr. Willard has frequently availed himself of this primary anæsthesia for minor operations, and, whilst agreeing with the statements of Dr. Packard, advises the operator who fails to perceive the anæsthesia of this stage and operates at an *inopportune moment*, (much to the patient's agony and to his own personal chagrin), not to be disheartened at his want of success, since it requires considerable experience to know just when the few seconds of primary anæsthesia have arrived that will permit of a painless operation.

According to Dr. Wood, the second stage of ether-narcosis may be considered to begin with the complete loss of consciousness; usually there is still some muscular rigidity present, which soon passes off and is followed by the complete anæsthetic stage, in which the patient lies quiet, with a slow, regular, automatic respiration and with the muscular system in a condition of perfect relaxation.

Deep, stertorous respiration, due to paresis of the muscles of the palate, should be the signal for the immediate withdrawal of the anæsthetic. The usual appearance of the face of the patient during etherization, and especially of the lips, is reddish; if marked pallor or lividity ensue,—important indications of cardiac and respiratory failure,—the ether is to be stopped at once, the feet of the patient elevated

and the head lowered until the color returns. The stage of exeitement generally lasts only a few minutes, but in some cases is prolonged, and in nervous women may pass into a violent fit of hysterics, which soon yields, however, to a persistent use of the anæsthetic (Wood).

Under ether, the *pulse* is quickened and increased in force, and it often maintains itself thus during prolonged narcosis. Should it weaken, it is usually only to a trifling degree. The *blood-pressure* is increased until very deep narcosis is induced, when a slight fall occurs. The rise of the pressure is probably due to an *increase of the power of the heart and to a stimulation of the vaso-motor nerves* (Wood).

According to Sansom ("Chloroform," p. 92, Philadelphia, 1866), a capillary constriction of the vessels takes place, as noted in the web of the frog's foot; this vaso-motor spasm is very permanent, and does not yield to paralysis and passive dilatation until the anæsthesia has almost deepened into death.

Ether brings about a marked change in the rhythm of respiration. If the full strength of ether vapor be allowed to impinge upon the glottis, the muscle is thrown into spasm and the rima becomes temporarily closed (Buxton). That ether has a marked local action upon the laryngeal muscles has been amply demonstrated by Horsley and Semon. They have proved that the action differs according to the degree of anæsthesia induced—in other words,

according to the amount of ether given. In their experiments, slight etherization produced adduction whilst more profound narcosis resulted in abduction of the vocal cords, these results being obtained both with strong and with weak currents and whether the recurrent laryngeal nerve was divided or left intact.

If the vapor of ether be taken in a concentrated form, there will usually be in the beginning a momentary arrest of respiration, accompanied by a decided sense of suffocation. As soon as this has passed off, the respirations are usually accelerated as well as deepened; but as the stage of anæsthesia is reached they become slower, and would eventually cease were ether pushed to so dangerous an extent. This slowing and final cessation appear to be due to the ultimate poisoning of the respiratory centre in the medulla.

The nervous system during etherization is profoundly affected. The functions of the brain succumb before those of any other portion of the nervous mechanism. Excitement and hallucinations appear, the patient believing that he is engaged in mortal combat or in some habitual pursuit. He may resist and cry out; soon, however, his speech becomes guttural and inarticulate, his struggles cease, and his mind no longer controls his movements. The posterior or sensory nerves then fail to convey impressions from without, although stimulation of the motor nerves induces movements. Later, the motor or anterior nerves also fail to respond to mechanical irrita-

tion, although the functions of the medulla oblongata are regularly performed, and stimulation of its anterior centres gives rise to motor disturbance, pricking of its sensory portions even causing manifestations of pain. When the inhalation of ether is still further pushed, the sensory and finally the motor functions of the medulla oblongata are involved, and death occurs from paralysis of the respiratory centres and the heart (Flourens, *Comptes-Rendus*, vol. xxiv., 1847). Longet states that he has never failed in any stage of ether-narcosis to get a response from the motor nerves by the employment of powerful electrical excitation.

Dr. H. C. Wood believes this apparent difference between the results obtained by Flourens and those obtained by Longet to be due to the fact that the former observer used only stimuli, whilst the latter employed powerful galvanic currents. Dr. Wood thinks that Flourens was substantially correct, and that the order of the involvement of the nerve-centres in man and in animals is—first the cerebrum, next the motor centres of the cord, next the sensory centres of the medulla oblongata, and finally the motor centres of the medulla oblongata.

The effect of etherization on the temperature of the body has been investigated by Dr. Hobart A. Hare (*Therapeutic Gazette*, May 15, 1888).

In his experiments he found that the rectal temperature of a dog fell from 8° to 10° F. after con-

tinuous etherization for an hour. Observations on twenty-six patients operated upon at the clinic of the University of Pennsylvania showed an average fall of 2½° F. The greatest fall was 4.4° F., in a case of sarcoma of both testicles; the least, 0.8° F., after the insertion of a drainage-tube in a case of empyema.

Duke (*British Medical Journal*, June 9, 1888), of Dublin, having noticed the collapse after prolonged ether-anæsthesia, suggests the use of a hollow operating-table, made of zinc or tin, which could be filled with hot water and would thus help to prevent the great fall of temperature in a prolonged operation.*

The elimination of ether is rapid, and is mainly effected through the lungs. With perhaps the exception of the urine, the secretions of the body are increased by the administration of ether.

Methods of Administering Ether.—Various mechanical contrivances for administering ether have been devised from time to time. Among these may be mentioned the inhalers of Allis, Hearn, Cheatham, Fowler,† Clover, Ormsby, Goodwille, Lente, and others.

Dr. Allis's inhaler, the best of all, consists of a

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* Annual of the Universal Medical Sciences for 1889.

† Dr. George R. Fowler published in the Medical Record, July 2, 1887, the description of an instrument to which he has given the name of "A Folding Allis' Ether Inhaler." It is square instead of oval, and by a neat mechanical arrangement can be folded nearly flat for transportation.

metallic frame (Fig. 1) sufficiently large to cover the lower part of the face. The bars are nearly a quarter of an inch broad, with a quarter of an inch between each bar and its fellow. The spaces are made by a punch, which removes a section from a solid sheet of metal. It will thus be seen that there can be no danger of the bars giving way, as there would be were they soldered upon a band.

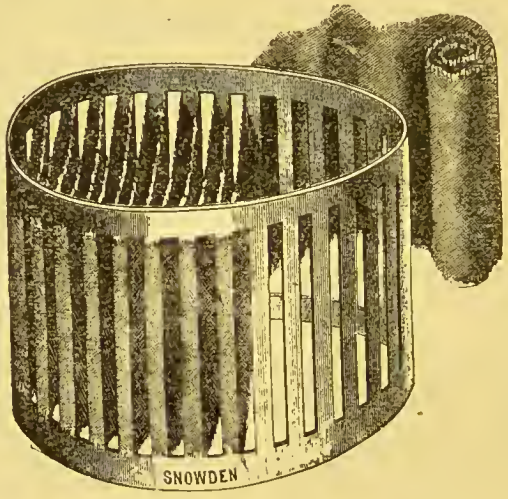

Fig. 1.

Over these bars a roller bandage is stretched by recurrent turns (Fig. 1), and the whole is enclosed in a leather cylinder. Dr. Allis does not consider this hood as essential. He much prefers a folded newspaper constructed to take its place, which after using can be destroyed. (Article in Keating's "Cyclopædia of the Diseases of Children," vol. iii, p. 916.)

The ether is poured over the layers of muslin which are stretched across the apparatus from side to side. (Fig 2.)

Fig. 2.

The advantages claimed for this inhaler by Dr. Allis are—

1. It gives the patient the freest access of air. It is a mistake to suppose that air must be excluded. All that is necessary is that *the air should be saturated with the vapor of ether.*

2. It affords a series of thin surfaces upon which the ether can be poured, and from which it will almost instantly evaporate.

3. By leaving the instrument open at the top, the supply can be kept up constantly, if desired; and,

as *ether vapor is heavier* than air, there is no loss by not covering it. *The top should never be covered.*

4. It does not cover the patient's eyes, does not terrify him; and he often passes under the influence of the anæsthetic without a struggle.

The mode of using the inhaler is as follows: It is placed over the face, covering the nose and the chin of the patient, who is allowed to breathe through it before any ether is applied, thus becoming accustomed to it and avoiding undue fright. Etherization is now begun with literally a few drops of ether; this will not irritate the larynx. Add, in a few seconds, a few drops more, and, as soon as the patient is tolerant of the vapor, increase the quantity gradually until the air breathed is saturated with the ether vapor. When the patient is fully influenced, the anæsthetic effect is to be kept up by the constant addition of a drop or so of the ether at a time; in this manner the average case can be fully etherized in from five to ten minutes.

This apparatus of Dr. Allis's fulfils the main indications for a successful administration of ether. The air inhaled is saturated with ether vapor, unsaturated air being excluded, the vapor does not escape into the room and impregnate the air breathed by the operators and by-standers, and during the first few respirations the patient inhales a vapor so dilute as not to irritate the larynx. A better instrument cannot be desired in cases where a special form of inhaler is called for.

The most simple, convenient, satisfactory, and always attainable inhaler is the cone, which is used to a large extent throughout the United States. It is made by folding an ordinary towel, (inside of which is a newspaper), into a cone with the apex open, the base of the cone being large enough to enclose the mouth and nostrils. The edges are rounded, and the sides pinned together with safety-pins. In the apex of this cone is placed a wet sponge or a piece of absorbent cotton, upon which the ether is poured through the aperture at the top of the cone.

The advantages of the cone over other inhalers used for the administration of ether are—that it is always attainable; it is an inexpensive apparatus, simple in construction; it is never employed with a second patient, which is a great advantage in the way of cleanliness; and, unlike the expensive and cumbersome instruments, it has no valves to get out of order, nor does its weight interfere with the patient's movements.

As we have already given in detail in Chapter II. the proper method of administering ether, it will suffice to say here that should the patient in the early stage of ether-intoxication manifest much excitement, a few gentle, assuring words, with the passage of the hand to and fro over the forehead, will generally restore quiet and confidence. Except when the individual persists in attempting to seize the hands of the administrator or to push away the inhaler, it is better

not to hold the arms or the legs, as the very feeling of restraint will provoke resistance.*

When given in a gradual manner, the full effect of the anæsthetic can be obtained without provoking any serious struggle; and whenever the long, snoring respirations begin, coupled with the absence of muscular reflex, the insensibility may be considered complete.

Fig. 3.

An excellent stopper for the ether-bottle is shown in the annexed cut. It is known as the *Perfection Ether Stopper*. It is cheap and simple in construction; the quantity administered being regulated by pressing the top button which is supported and

*Dr. D. Hayes Agnew, Surgery, Vol. II.

kept in position by a spring. Its size is such that it will fit any ordinary bottle.

Dr. John B. Roberts, of this city, after using, with varying degrees of dissatisfaction, various utensils for holding the anæsthetic during the time of administration, finally had made a graduated white glass bottle, with a rubber stopper and wire-spring clamp, like that used for sealing effervescent drinks. A cork, perforated by two small tubes, is attached to the bottle by a drain, and is to be inserted when the anæsthetic is to be used. These bottles are a great convenience; and being made of strong glass, are not readily broken. The accompanying cut shows the bottle.

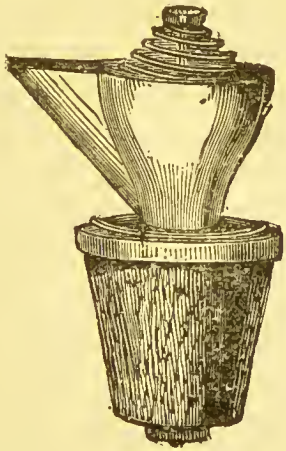

FIG. 4.

Rapid Anæsthesia by Ether.—The following method of rapid anæsthesia by ether suggested itself to

A. F. Müller, M.D., attending physician at the Germantown Hospital, seven or eight years ago, through an idea that the great length of time often consumed in etherizing patients was due to the frequent interruptions necessary to replenish the cone or the towel. To obviate this difficulty, and obtain a continuous flow of pure ether vapor, he devised an apparatus consisting of the two halves of a rubber foot-ball, sewed together at the edges, and connected by a tube with a bottle containing ether, which latter is plunged into a bucket of hot water. As ether boils at 90° F., the vapor passes from the bottle steadily and rapidly, and is inhaled by the patient, whose face is covered by the inhaler, protected by a clean towel.

The result was surprising to the Doctor himself, for in none of the eighteen cases etherized by this method was there nausea subsequent to anæsthesia. At least one patient came to the house on the morning of the operation after eating a hearty breakfast. In most of the cases no struggling occurred, and when it did occur it was only slight; there was no stage of excitement. After the patient was etherized, the amount of the vapor passing over was regulated by a stop-cock at the bottle end of the tube. In no instance did the quantity of ether used to produce complete insensibility exceed three ounces; in some cases it was less than an ounce and a half (Turnbull, *loc. cit.*).

Contrary to the above experience, however, Dr. Robert Lovett has reported lately some careful ob-

servations in a series of sixty consecutive cases at the Boston City Hospital.* He used two methods: one, which he calls the gentle method, in which the ether was given slowly and cautiously; the other, the "forcible" method, in which the cone was at once applied closely to the nostrils and mouth of the patient. The former method required an average time of 9.3 minutes and an average amount of 2.5 ounces for complete anæsthesia. The latter required only 4.4 minutes and 1.5 ounces, but the choking sensation was very much aggravated and the patients were very apt to retch and struggle violently if they inhaled but a breath of air.

Dr. White, in the article referred to (*loc. cit.*), says that the experience of Dr. Lovett corresponds substantially with his own in the use of the rapid method, by which the ether contained in a bottle was dropped in a bucket of hot water by the bedside, the vapor being conveyed by a long flexible tube to a mask placed tightly over the mouth and nose of the patient. The average time required for producing insensibility in some dozen cases was considerably less than a minute,—about forty-three seconds,—and was often within a half-minute; but the condition produced was one of asphyxia rather than of true anæsthesia; the distress of the patients was very great, and the evidence of excessive increase of vascular tension

*Quoted by Dr. J. William White, Medical and Surgical Reporter. March 9, 1889.

was so unmistakable and sometimes so alarming that after a fair trial he gave up the method, believing no economy of time or of ether would compensate for the slightest increased risk to life.

It is hardly necessary for us to say that, such being the experience with this method of producing rapid anæsthesia, we mention the subject only to condemn it as dangerous to life and in no wise compensating for the risks to which the patient is subjected.

Dr. Corning, of New York, has used the following plan to produce rapid anæsthesia: A strong, flat, elastic tourniquet is secured around each of the patient's thighs, so as to arrest both the arterial and the venous flow of blood in the lower limbs. The ligature being in place, the ether cone is applied over the mouth and face of the patient, and in about three minutes complete etherization is accomplished. This method cannot be considered seriously, because of its impracticability, few persons being able or willing to endure the intense pain produced by the elastic bands.

Etherization by the Rectum.—The possibility of producing artificial anæsthesia in the human being by way of the rectum was demonstrated by M. Roux,† of Paris. During the same year, Dr. Nedo ‡ made some experiments upon rabbits by injections of ether into the lower bowel; he successfully produced anæsthesia, but as a

† Compte-Rendu de l'Académie des Sciences, February 1, 1847.

‡ Gazette Médicale de Paris.

result of the administration an intense enteritis ensued, followed in some instances by the death of the animal. Pirogoff, of Russia, was the first to induce insensibility in the human subject by means of ether vapor per rectum. The advantage of administering ether by this method as claimed by its advocates are many, but, as they are outnumbered by its disadvantages, we will not occupy space by their enumeration; suffice it to say, therefore, that this plan, so far as its practical application is concerned, has not met with professional favor.

The time required for the production of complete anæsthesia by ether administered in the ordinary way varies greatly in different individuals, some requiring not more than from six to eight minutes, while others are affected only after twenty or twenty-five minutes. The average time, according to our experience, is from ten to fifteen minutes, the amount of ether required varying from four to five ounces.

Recovery from Ether-Anæsthesia.—The manner in which recovery takes place differs in different cases. In some instances, patients will awake quietly out of sleep, at first somewhat confused or bewildered, but soon able to collect their thoughts in an orderly manner, and to speak intelligently, though not having the least idea of the lapse of time, and expressing great surprise, amounting in some cases to unbelief, when told that the operation is over. Others, unless aroused by a shake or addressed in a loud voice, will continue

to sleep quietly for half an hour or longer after the withdrawal of the anæsthetic; while in other cases recovery is characterized by incoherent or ludicrous babblings.

After-Effects of Ether.—The most common sequels of ether-inhalation are nausea and vomiting, headache, hiccough, and sometimes an irritating cough. In females, nervous symptoms of an hysterical nature are frequently witnessed.

Usually the nausea and vomiting will pass away in an hour and medication will not be found necessary. When it is more persistent, chipped or shaved ice may relieve it. When retching is constant, a full tumbler of hot water, or of tea, will give relief. One drop of hydrocyanic acid or five drops of chloroform in a little mint-water will be found to act well; but the most efficacious remedy is a hypodermatic injection of morphine.

The headache usually requires a night's rest for its removal; but some relief may be afforded by administering aromatic spirit of ammonia in camphor-water. Ice applied to the head often aids in mitigating the pain. Hiccough, which is sometimes very severe after ether, may be cured by such remedies as musk, chloral, or morphine (the latter administered hypodermatically).

The cough, which is due to the local action of the ether on the bronchial mucous membrane, usually subsides in a short time. When this does not occur,

counter-irritation over the chest, combined with the internal administration of some anodyne cough mixture, will usually suffice for its relief.

Hysterical symptoms are best met with the use of morphine or bromide of potassium.

Dangers and Accidents of Ether-Narcosis.—The collection of tenacious mucus, which frequently forms in the pharynx, should be cleared away from time to time. This can be most conveniently done by the finger wound round with a towel or handkerchief. This collection of mucus, in the case of infants and weakly persons, may prove a grave after-complication, giving rise to blocking of the bronchial tubes and to œdema of the lungs.

Vomiting may occur, and is usually announced by short, convulsive movements of the muscles of the abdomen. Frequently by pushing the anæsthetic at this point the vomiting can be prevented. When it does occur, two indications are paramount: first, to get rid of the vomited matter, and to avoid its entrance into the larynx by the deep inspiration which always follows: second, to secure complete return of conciousness. To meet these indications, the patient's head should be turned to one side without being raised, the ether withdrawn, and all ejecta removed with the finger. Should the breathing be interfered with and the face become purple, resort should be had to the measures described in the following paragraphs. In jaw-anchylosis the condition becomes one of extreme danger.

Troubles Connected with Respiration.—The chief troubles which occur during ether-narcosis are connected with respiration. When the breathing becomes short and stertorous and the face purple, without any sign of the reëstablishment of respiration, the head should be promptly lowered, and the tongue seized and drawn out of the mouth by the forceps or a tenaculum. This must be done, not because the glottis can be thus opened, but on account of the reflex actions of respiration which may be excited. Sometimes the teeth may be forcibly closed at this stage, simulating lock-jaw. They can usually be separated by a screw gag, or pried apart by some other means—the fingers, etc.

The breathing may be excited by slapping the face, neck, and breast with a towel dipped in cold water. Dr. Hobart A. Hare (*University Medical Magazine*) states that when there is embarrassed respiration, or temporary suspension of the inspiratory effort, in place of resorting to flagellation with towels wet with cold water, a little ether poured upon the abdomen or chest will cause, by the shock occasioned by the cold produced, a deep inspiration. If these precautions fail to avert the asphyxia which is impending, artificial respiration must be tried, either by the Sylvester or the Marshall Hall method.

Sylvester's Method.—Place the patient on the back, with a block or a pillow under the shoulders, and raise the arms above the head, grasping them

above the elbow, and pulling firmly and steadily as long as there is any sound of air entering the chest. As soon as the sound produced by the entrance of air into the chest ceases, the arms should be brought down a little toward the front of the chest, and pressed firmly and steadily against it for about one second after air is heard escaping. In order to get rid of the vapor of the anæsthetic in the chest, the repetition of this operation should be more quickly performed than in cases where it is done to resuscitate the drowning,—about once every two or three seconds. The movement should be kept up until the patient is thoroughly restored from the dangers of asphyxia.

Marshall Hall's Ready Method consists in placing the body on one side, and alternately rolling it on its face to compress the chest, and on the back to allow the ribs free movement to draw air into the lungs. The plan is not so effective as Sylvester's method in the majority of cases.

In these cases of failure of the respiration, when time permits and the appliance is at hand, the employment of the electro-galvanic battery is of great service, the current being passed along the phrenic nerve and over the wall of the thorax. A powerful current should never be used; and the application of electricity should be restricted to the right side of the body, so as to avoid the risk of arresting the movement of the enfeebled heart.

Hypodermatic injections of brandy or whiskey, and of digitalis, strychnine or atropine, are also indicated. In reference to the use of atropine, we desire to call particular attention to the fact that, in dangerous symptoms following the use of an anæsthetic, the remedy, though serving to accelerate the respiratory centres and the cardiac contractions, has a decidedly paralyzing effect upon the cardiac branches of the pneumogastric; so that, while theoretically it may protect the heart from violent inhibitory shocks transmitted through the vagi, it is doubtful whether, in medicinal doses, it can effect any greater benefit than may result from the action of the anæsthetic itself.*

It rarely happens that the heart occasions trouble in etherization. In a few recorded cases, fatal syncope has occurred at the beginning of ether-inhalation, but whether such casualties can be justly attributed solely to ether-influence is doubtful.

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* Henry M. Lyman, M.D., Ashhurst's Encyclopædia of Surgery, vol. i, p. 403.

CHAPTER IV.

CHLOROFORM.

There are three claimants to the honor of the discovery of chloroform ($CHCL_3$),—Liebig, of Germany, Soubeiran, of France, and Guthrie, of America. In our opinion the weight of evidence shows that Dr. Samuel Guthrie, of Sackett's Harbor, New York, is entitled to the honor of first discovering chloroform, In 1831. Its value in medicine was early recognized by Professor Ives, of New Haven, Connecticut, who in 1832 employed it for the relief of pulmonary spasm. Its anæsthetic use upon the human subject was due to the advocacy of Sir James Y. Simpson, in 1847, after it had been introduced to his notice by Mr. Waldie, of Liverpool.

Chemical and Physical Properties.—Chloroform is a colorless, highly refractive liquid, possessed of an agreeable, aromatic odor, and a sweetish, pungent taste. When exposed for some time to light, it splits up into chlorine and hydrochloric acid. It is very volatile, but, although mixing freely with air, pure chloroform vapor can exist only at a temperature of 140° F.

In the U. S. Pharmacopœia, chloroform is officinal in two forms:—*Chloroformum Venale*,—Commercial Chloroform; and *Chloroformum Purificatum*, —Purified Chloroform. It is the latter form of the

drug which will receive our consideration in this chapter.

Physiological Action of Chloroform.—Applied to the skin, chloroform is a powerful irritant, and, if the contact be prolonged and evaporation be prevented, vesication will ensue. It is therefore highly important to guard against these effects during the administration of chloroform, by protecting the face with vaseline. Taken into the mouth, chloroform occasions a burning sensation, and, when swallowed, a sense of warmth in the stomach. Anæsthesia and poisoning may follow the swallowing of a considerable quantity.

The vapor of chloroform, when inhaled, produces symptoms not unlike those induced by ether, except that the choking sensations are absent, and that the stage of excitement is generally, though not always, shorter and less violent than that of etherization (Dr. H. C. Wood, *loc. cit.*).

Dr. Buxton (*loc. cit.*) divides chloroform-narcosis into five stages. Dr. Snow ("On Anæsthetics," London, 1858) mentions but four stages. According to Dr. Wood and most other authorities, the division proposed by Sabarth ("Das Chloroform," Würzburg, 1866) is adopted as the more useful and practicable. By this classification three stages are recognized:

In the first of these stages the symptoms are similar to those of alcoholic intoxication. This stage is usually of short duration, but in athletic persons, and particularly in those who have been intemperate,

it may be prolonged and the patient be very violent, even after the loss of consciousness. In drunkards this excitement at times cannot be overcome without grave danger to life. During this period, although consciousness is not lost, the sensibility is generally blunted, but very rarely is it entirely annulled. Dr. Coleman (Sansom, "Chloroform," 1866, p. 55), as quoted by Dr. Wood, states, however, that he has extracted his own teeth in this stage without pain. Dr. Snow, quoted by the same authority, is cited as relating the anecdote of a child who played with his toys during the operation of lithotomy.

During the second stage, which is that of anæsthesia, consciousness and sensibility are abolished, the muscles are relaxed, and the patient lies perfectly quiet. It is at this stage that ordinary operations are performed. In some cases the first and second stages are united, so that violent excitement, muscular spasm, and rigidity may coexist with loss of consciousness and of sensibility.

The third stage is one of profound narcosis; the breathing is stertorous, the pupils are dilated, and the muscles are completely relaxed and flaccid. All reflex action is abolished. This stage denotes a condition of danger, and its induction by chloroform, except under very peculiar circumstances, is absolutely unjustifiable (Wood).

The pulse, in the first stage of chloroform-narcosis may be quickened, even apparently strengthened; in

the *second stage* it is generally about normal in frequency, but is more or less weakened; in the *third stage* it may be rapid and weak.

The temperature usually rises during the *first stage*, falls slightly during the *second stage*, or remains above normal, and falls decidedly during the *third stage* (E. Simonin, *Centralb. f. Chirurgie*, 1877, p. 234).

The *respiratory function* exhibits a greater degree of irregular disturbance under the influence of chloroform than any other series of vital phenomena The movements of respiration are generally increased in number at the commencement of inhalation, and may become irregular, jerky, and sighing. Sometimes they become exceedingly restricted and almost imperceptible. An extreme rigidity of the abdominal muscles may limit the movements of the diaphragm. The act of inspiration may be shortened while that of expiration is prolonged, and if the inhalation is persisted in, the respiration becomes more and more shallow, irregular, and distant, finally ceasing entirely. Just here we may properly consider the report of the Hyderabad Chloroform Commission* upon the two different series of investigations carried on in India at the expense of the Nizam of Hyder-

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*For an able discussion of this report, see article in the Therapeutic Gazette for August and September, 1890, pp. 515 and 589, entitled "The Value, Relations and Dangers of Anæsthetics," by Dr. G. Archie Stockwell, of Detroit, Mich.

abad. The *first* commission was composed of Dr. Hehir and Messrs. Kelly and Chamarette; the *second* included the above-named gentlemen, together with Surgeon-Major Lawrie, Dr. G. Bomford, Dr. T. Rustamjé Hakim, and a representative of the London *Lancet*, Dr. T. Lauder Brunton. The deductions drawn from the experiments made by these two commissions agreed, in the main, with one another.

The conclusions reached by the Commission, briefly summarized, are as follows: Chloroform, given continuously by any means which insures its free dilution with air, causes a gradual fall in the mean blood-pressure, provided that the animal's respiration is not impeded in any way, and that it continues to breathe without struggling or involuntary holding of the breath. . . . If the chloroform is less diluted the fall is more rapid, but it is always gradual so long as the other conditions are maintained; and, however concentrated the chloroform may be, *it never causes sudden death from stoppage of the heart.* . . . Struggling during chloroform-inhalation, or anything which in any way interfered with the breathing, such as holding the breath or asphyxia, produced irregularities in the circulation and in the action of the heart. Even such slight interference as was brought about by forcibly pulling the tongue forward had this effect. In fact, pulling the tongue forward, which is constantly done when patients are supposed to be in danger from chloroform-narcosis, was the only pro-

ceeding, short of direct irritation of the vagus, that appeared to produce shock. It is possible to give chloroform in such a way that full anæsthesia shall be produced, with a gradual fall of blood-pressure, unaccompanied by any irregularity of the heart or circulation. The way to do this is to insure natural and regular respiration, without struggling, holding the breath, asphyxia, or any interference with the breathing. . . . Death from chloroform is invariably due to an over-dose. . . . Complete asphyxia or continuous holding of the breath, if this latter were possible, would be a sure preventive of poisoning by chloroform; but the danger in such conditions is due to the fact that they must alternate with extra-vigorous and deep respiration. Struggling makes the inhalation of chloroform dangerous, because it either partially asphyxiates the patient, or alternately does this and accelerates the respiration and circulation, thus increasing the amount of chloroform inhaled and hastening the rapidity with which the anæsthetic is conveyed to the brain and nerve-centres. Holding the breath causes asphyxia, and asphyxia produced in this or in any other manner, poisons and stimulates the respiratory centre, making it extremely liable on the one hand to paralysis, while on the other it leads to gasping and deep inspirations, by which an over-dose is very soon inhaled. The rapidity of chloroform-poisoning when asphyxia is produced is much the same as it would be if a man were thrown

into a pond and a chloroform-inhaler held over his head every time he came to the surface to take a breath. This is exactly what a timid or badly-taught anæsthetizer often does. . . . The anæsthetic must be administered in an open cone or cap, which is held far enough from the patient's face to avoid causing him to hold his breath or to struggle, and into which he is at first made to blow after each inspiration, the cap being brought gradually nearer to the face, and eventually quite close to it, as the chloroform begins to take effect and he breathes regularly. . . . The reflex winking when the eye is touched is of value as an index to the state of anæsthesia. . . . If the breathing becomes embarrassed, the lower jaw should be pulled or pushed from behind the angles forward, so that the lower teeth shall protrude in front of the upper. This will raise the epiglottis and free the larynx. At the same time it will be advisable to assist the respiration artificially until the embarrassment has passed off. . . .

The previous administration of alcohol, the Commission say, may be resorted to, "provided it does not cause excitement, and merely has the effect of giving a patient confidence and steadying the circulation."

The Commission approved of the custom with some physicians of giving a dose of morphine hypodermatically ten or fifteen minutes before the administration of chloroform. They state that there is

nothing to show that atropine does any good, and that "it may do a great deal of harm." . . . As a final conclusion, the Commission says that if the rules suggested be followed, "*chloroform may be given in any case requiring an operation with perfect ease and absolute safety, so as to do good without the risk of evil.*"*

Hardly had the announcement of the above report of the Hyderabad Commission reached the mass of the profession, when a series of parallel experiments undertaken by Dr. H. C. Wood and Dr. Hobart A. Hare were published in the *Medical News* for February 22, 1890. In this article the writers say:

"As we use between us, in the laboratory of the University of Pennsylvania, many dogs yearly, a very large proportion of which are finally killed by chloroform, we may be excused for our positive statement that *chloroform is a cardiac paralyzant*, and does kill dogs by direct action upon the heart or its contained ganglia; especially since we have been strengthened in our opinion by the fact that Dr. E. T. Reichert, Professor of Physiology at the University of Pennsylvania, has reached results confirming our own, and has frequently demonstrated the same to the University classes. . . .

"It has been the custom of one of the authors of this paper, in his lectures before the University class, to demonstrate, by means of the respiratory tambour,

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* A somewhat swecping assertion.—AUTHORS.]

the mercurial manometer, and the kymographion, a continuation of respiratory movements after cardiac arrest through chloroform. Further than this, we have at various times taken tracings proving the same facts.

"The statements that have recently been made in the Indian journals, and in the London *Lancet*, have led us to reëxamine the subject, and to make a series of experiments upon it with great care. We have also varied and extended these experiments in order to determine whether chloroform paralyzes the heart by direct influence or by an indirect action through the vagus. . . . In all cases accurate tracings have been made by means of the kymographion and the respiratory tambour. . . .

"The experiments show that chloroform acts as a powerful depressant poison upon both respiration and circulation; that sometimes the influence is most felt at the heart, and death results from cardiac arrest; that in other cases the drug paralyzes primarily the respiratory centres, while in other instances it seems to act with equal force upon both medulla and heart. So far as practical medicine is concerned, it makes little difference whether the heart stops just before or just after respiration, so that those cases in which cardiac arrest and respiratory arrest are almost simultaneous are, for the purposes of the clinician, the same as those in which heart-arrest precedes respiratory paralysis. Finally, the results of our new ex-

periments also coincide with our previous experience in the laboratory, and with what we believe to be the general belief of physiologists,—that cardiac arrest is specially prone to occur when chloroform is administered rapidly and in concentrated form."

These two sets of experiments show quite different results. The most plausible explanation as to the cause of this difference is found in Dr. H. C. Wood's address on "Anæsthesia," read before the International Medical Congress, Berlin, August 6, 1890.† Dr. Wood therein stated that he did not desire to express any doubt whatever as to the correctness of the experimental data of the Hyderabad Chloroform Commission, but simply claimed that both his and their set of experiments, although they had yielded different results, had been properly performed. He suggested that the high heat or other climatic conditions surrounding the pariah dog of India might make its heart less sensitive to the action of chloroform than the heart of the dog bred in our northern climates. That the idea of the varying constitutions of animals in different climates is not absurd, was shown, Dr. Wood stated, by the fact that some years ago, after he had affirmed before the Physiological Section of the International Medical Congress at London that if certain asserted results were obtained upon European dogs, said dogs must

† Published in the Medical News, August 9, 1890.

differ from those of America, and the assertion had been met with a smile of incredulity, Dr. Brown-Séquard stated that he had experimented upon hundreds of dogs on both continents, and that there was a distinct difference between the animals, the vascular system of the European dogs being much more developed, and operations upon them being, therefore, much more bloody than was the case with the American dog. Dr. Wood also cited a very curious parallel which might be traced between the experimental and the clinical evidence in regard to the effect of climate upon the action of chloroform. In the Southern United States, chloroform is used with great freedom and with alleged safety; and so long ago as 1878, Dr. Landon B. Edwards, editor of the *Virginia Medical Monthly*, wrote: "It is one of the most peculiar facts I have ever known in medical practice,—the difference of experience in Europe and the North with chloroform and ether, as compared with that of the South,—the high rate of mortality in the North, and the low rate in the South."

From this *résumé* of the physiological action of chloroform upon the circulation and respiration as deduced from recent experimental study we find, not the discord which at first sight is suggested between the clinical and the experimental evidence, but a beautiful concord, or, as tersely expressed by Dr. Wood, "a concord between experimental and practical medicine which so often fails to appear simply because we can-

not fit together the fragments of truth in our possession."

Upon the *nervous system*, the action of chloroform, like that of ether, is chiefly upon the brain and spinal centres. It produces anæmia of the brain, and has but a slight action on the peripheral nerves. Dr. H. C. Wood thinks it very doubtful how far the muscular excitement of the second stage is due to real spinal exaltation, and how far it arises from other causes. Harley's observations on the action of chloroform on the respiratory function of the blood tend to show that it lessens the oxidation of the blood and diminishes the evolution of carbonic acid.* To establish this fact, however, according to Dr. Sydney Ringer, further experiments are needed.

Chloroform is, at least in part, eliminated as such through the skin, breath, and urine. Albuminuria has been noted both in animals and in man after narcosis from this drug.

"Chloroform enters the blood until an equilibrium is established between the tension of chloroform in the residual air in the lungs and that in the serum. So long as the tension in the air is maintained above or equal to that in the blood, no chloroform can leave the serum through the agency of the pulmonary mucous membrane.

"The amount of vapor which can be taken up

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*Physiological Transactions, London, 1865.

(held in solution) by the air of the atmosphere varies with the elastic tension of the chloroform vapor at different temperatures. Thus, at 40° F. a small quantity of chloroform would evaporate into air; at 130° F. so much would volatilize as to give rise to an almost pure chloroform vapor. Any proportion of chloroform above two grains in the hundred cubic inches of air causes interference with respiration; three grains in the hundred secures about the ratio which renders respiration impossible. Three grains represent 2.3 cubic inches of vapor; and as air at 100° F. can take up 45.3 per cent of its volume, the blood must contain from $\frac{1}{19}$ to $\frac{1}{18}$ of the proportion it is capable of absorbing when the respiratory centres are poisoned.

"Snow found further that, calculating the weight of the blood as thirty pounds, twelve minims of chloroform in the circulation produced narcosis of the first degree, eighteen minims the second degree (surgical anæsthesia), and thirty-six should paralyze the medullary centres. In practice more is needed, because a certain proportion evaporates from the tracheal and bronchial surfaces and is carried out in respiration. If twelve minims be evaporated into a bladder and inhaled to and fro, no more air being allowed than can be blown from the lungs, narcosis of the first degree actually results. Now, taking thirty-six minims as a lethal dose, the following considerations, upon which Snow strongly insisted, explain

how easily this quantity may enter the circulation if the administrator be not perpetually upon his guard against over-dosage: 18 minims represent the amount absorbed to produce surgical narcosis; this amount might be absorbed by the use of 36 minims, the remaining 18 minims being exhaled as above mentioned. These 36 minims represent 37.5 cubic inches of vapor, which at 60° F. would require 257 cubic inches of air. The 300 cubic inches thus formed would be inspired in twelve respiratory acts (25 cubic inches being the amount of tidal air). Now, if a vapor of this strength were continuously inhaled, the residual and complemental air would become saturated; and, as about 250 cubic inches represent the air in the lungs, this amount would at 90° F. contain the vapor of 30 minims.

"Assuming only half this quantity to be absorbed, —that is, 15 minims,—we would then have 18 + 15 or 33 minims in the blood, an amount almost, if not quite, enough to paralyze the respiratory centre.

"These points being held in remembrance will explain many cases of chloroform death ascribed to 'idiosyncrasy' or to the 'fatty heart' which stands inexpert chloroformists in such good stead. Death from chloroform does not, however, always result from respiratory paralysis.

"Working in the same line as Snow, Paul Bert examined the action upon animals of a small percentage of chloroform vapor in air. He asserted that atmospheres containing chloroform below a certain

percentage failed to induce anæsthesia; below a higher percentage (*zone maniable*) produced anæsthesia without danger to life, even when a vapor of this strength was persisted in for an indefinite period, while above this higher percentage death always occurred. The lethal percentage he found to be double the smallest quantity necessary to induce anæsthesia. Lister, who repeated Bert's experiments, found no true *zone maniable* (working zone) to exist. Indeed, the French observer appears to have overlooked the important fact that chloroform kills not only by paralysis of the heart, but also by failure of respiration. Richardson, whose views seem to differ from those who adhere to this percentage theory, suggests that death from chloroform is due, when it occurs in the latter stage, to the cumulative action of the drug" (Buxton).

Methods of Administering Chloroform.—The administration of chloroform for anæsthetic purposes falls naturally under two divisions: 1, when an inhaler is used; 2, when the open method is employed.

INHALERS.

Various inhalers have been devised with a view of regulating the amount of chloroform used, and of securing the proper admixture of air. Speaking of inhalers, Dr. John Ashhurst, Jr., says that he believes "that the greatest safety to the patient is the sense of immediate responsibility which should always be felt

by the giver of chloroform, and that hence the best inhaler may occasionally prove injurious by inspiring a false sense of security."

Clover's Chloroform Apparatus, as described by Erichsen,* consists of a bag holding eight thousand cubic inches of air, which is suspended from the coat-collar at the back of the administrator, and connected with the face-piece by a flexible tube. The bag is charged by means of a bellows measuring one thousand cubic inches; and the air is passed through a box warmed with hot water, into which is introduced, at each filling of the bellows, as much chloroform as is required for one thousand cubic inches of air. This is done by means of a graduated glass syringe, adjusted by a screw on the piston-rod to take up no more than the quantity determined on, which is usually from thirty to forty minims.

When the bag is full enough, the tube is removed from the evaporating vessel, and the mouth-piece adapted to it. The patient cannot get a stronger dose than the bag is charged with; but the proportion can be made any degree weaker by regulating the size of an opening in the mouth-piece, which admits additional air.

Snow's Inhaler, as described by Buxton (*loc. cit.*), consists of a metallic cylindrical vessel, in which four stout wires descending nearly to the bottom fix two

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* Science and Art of Surgery, vol. i, p. 44.

coils of blotting-paper which go quite to the bottom. The coils are cut into four, and are thus allowed free circulation of air, which enters through perforations in the upper part of the cylinder. Outside this part of the apparatus is another cylinder, which is filled with cold water. A glass tube communicating with the interior passes to the outside, and so enables the administrator to see when fresh chloroform is required. The face-piece is fitted with an expiratory and an inspiratory valve, the latter communicating with a three-quarter-inch tube fixed to the inhaler. The air enters through perforations in the upper part of the inhaler, passes down through the notches and takes up chloroform vapor volatilized from the bibulous paper, and thence passes up the centre of the inner cylinder into the tube attached to the face-piece.

During inspiratory efforts the valve trapping this tube permits of chloroform vapor entering the patient's lungs, while during expiration this valve closes, and the patient freely evacuates his lungs through the expiratory valve. From two to two and a half drachms of chloroform are placed in the inhaler at once, more being added from time to time as this evaporates.

Sansom's Inhaler is described by Dr. Buxton as a modification of Snow's apparatus. The receiver is a cylinder three inches high by one and one-half inches in diameter, filled with a coil of lint, upon which the chloroform is poured. The top is provided with a

freely-perforated plate, through which air passes to become impregnated with chloroform. The receiver communicates by an exit tube with a face-piece, to which are attached inspiratory and expiratory valves. The receptacle is covered with gutta-percha, which Dr. Sansom believes equalizes temperature better than the cold-water jacket of Snow.

In Junker's Inhaler as modified by Buxton, half an ounce of chloroform is poured into a bottle through a funnel-shaped opening fixed in a tightly-fitting screw-top, through which pass two tubes, a long one connected with a Richardson's bellows and a short one connected by means of india-rubber tubing with a vulcanite face-piece; air is then pumped through the chloroform, and in its passage takes up the vapor. The foot-bellows are fixed by straps, one of which slips over the toes, while the other receives the heel in the longer loop. When the foot presses lightly, the air in the bellows is forced through the tube into the bottle, then through the other tube to the face-piece. In the tube connected with the bellows is a net-enclosed rubber ball for equalizing the stream of air and for the avoidance of splashing. It is important not to put more than half an ounce in the bottle at once, and not to pump in air spasmodically or too forcibly, as otherwise chloroform may be driven through the system of tubes into the face-piece. Even if this does not happen, Dr. Buxton says that a strong blast of chloroform-impregnated air is very

unpleasant and deleterious if allowed to impinge upon the face. When the bottle has become nearly empty, the milled-headed stopper which closes the funnel is removed and more chloroform added.

Many other inhalers might be enumerated, but, as the principal ones have been described, it is needless to dwell longer on the subject.

THE OPEN METHOD.

In this country the open method for the administration of chloroform is the one generally employed, having proved to be the safest and therefore the best.

A towel or napkin is folded into a kind of cup-shaped hollow, and held securely in the hand; upon this is poured the chloroform. At first it is held two or three inches from the nose of the patient, the distance being gradually lessened as the effects of the vapor begin to be produced. The quantity of the anæsthetic used at one time should not exceed half a drachm, a few drops being added from time to time as required. The amount of chloroform required to produce full anæsthesia will vary in different persons. Those who indulge freely in alcoholic drinks or in opiates will require considerably more than persons who are free from such habits. From two drachms to half an ounce is the quantity usually found necessary (Dr. D. Hayes Agnew, *loc. cit.*).

The time required for the completion of anæsthesia ranges from four to seven minutes.

Dr. Samuel D. Gross, with whom chloroform was a favorite anæsthetic in his surgical practice, was accustomed to lay stress upon five principal circumstances which should be closely attended to during the administration of this drug, the observance of which—unless the article were a bad one, or the patient possessed some idiosyncrasy—he maintained would obviate any unpleasant results. These were *recumbency*, *an empty stomach*, *a free play of the diaphragm*, *an abundance of atmospheric air*, *and gradual administration.*

The following points should be attended to in preparing a patient for chloroformization. The *stomach* should be empty, by timing the inhalation, when possible, at an interval of several hours after a meal, and by having that meal as light as is consistent with the patient's condition and the operative procedure. The clothing must either be removed or be made very loose about the neck, chest, and waist, so as to permit of free breathing. *False teeth* must be removed. Some authorities advise the administration of a cardiac stimulant shortly before commencing the inhalation of chloroform; others, and probably the majority of administrators, do not. When it is deemed advisable to resort to such a stimulant, a tablespoonful or two of spirits—brandy or whiskey—may be given.

The patient, being ready, should be laid flat upon the operating table, or the bed. All unnecessary con-

versation is to be avoided, as otherwise the attention of the patient is apt to be unduly distracted. The administrator must give his undivided attention to his duty, keeping a watchful eye upon the *pulse*, the *respiration*, and the *color of the face;* his vigilance increasing as the effects of the medicine become more and more apparent.

Snow speaks favorably of an admixture of eau de cologne, one or two parts by measure, with chloroform, when the latter drug is administered as an anæsthetic by the open method. His theory is that it has a favorable action by lowering the elastic force of the vapor of chloroform, and diminishing the amount of vapor which is given off from the towel or napkin, just as diluting a strong solution of ammonia with water diminishes the amount of the volatile alkali which escapes as gas. Very little of the cologne is inhaled, as the greater part remains behind after the chloroform has evaporated. Dr. Willard has used this admixture in operations upon children with gratifying results, the agreeable odor of the cologne-water concealing the unaccustomed smell of the chloroform.

When the patient begins the inhalation of chloroform, it is advisable to request that the breathing be gentle and quiet, much in the same fashion as if natural sleep were ensuing; for if the breathing be deep, the vapor feels much more pungent than it otherwise would, and is apt to excite coughing, or a

feeling of suffocation. With children and timid persons, it is desirable to give the vapor in a very diluted state at first, in order that the air-passages may become gradually accustomed to its presence.

Some persons become excited as soon as they begin to reach the stage of unconsciousness, and attempt to rise, or to push away the chloroform. Under such circumstances, if the patient cannot be calmed by a few gentle words, he should be lightly restrained, and the vapor gently and steadily continued for a minute or so, until the state of quietude is produced.

There is usually no difficulty in ascertaining whether a patient is conscious or not; if the eyelids remain open, the countenance gives a reliable guide; if they are closed, the eyelids should be gently opened, and the cilia lightly touched with the forefinger; should no blinking occur, the operation may be commenced. To this rule, however, children and hysterical females form exceptions (Buxton).

In these latter cases, one must be guided by the other symptoms, and also by the length of time the inhalation has continued, the strength of the vapor, and the depth and frequency of the breathing.

The conditions noted in the early portion of this chapter, under the head of the physiological action of chloroform in the second stage, may be maintained, with due caution, for some time; but if now the chloroform is continued in undiminished quantity, the breathing becomes noisy and stertorous; the pupils

are greatly dilated; the pulse loses its strength; the breathing grows more and more shallow, and less and less frequent, till both pulse and respiration stop. Even now, artificial respiration will often restore the breathing, bring back the pulse-beats at the wrist, and rescue the patient from impending death. Dr. Ringer, on several occasions, has witnessed recovery from this critical condition.

Sometimes, on the other hand, while the pulse is beating well and the breathing is deep and quiet, the heart suddenly stops without warning, and respiration immediately ceases. When death occurs under these circumstances, it probably arises from cardiac syncope; while the form of death alluded to in the preceding paragraph is probably due to gradual paralysis of the respiratory muscles from the effect of the drug on the centres of respiration (Wood; Ringer).

The pulse, during the administration of chloroform, usually maintains its frequency and force throughout; should it become quick and weak, or irregular, the inhalation must be withheld, unless the frequency of the beats can be accounted for by the patient's struggles.

If the breathing, which frequently affords an earlier sign of danger than the state of the pulse, becomes very shallow, and gradually less frequent, the administration should be suspended for a time.

The surest signs of safety, and the earliest symptoms of danger, are afforded by the state of the pupil.

When no danger is to be apprehended and the patient is insensible, the pupil is much contracted; but on the approach of peril from over-dosage of the anæsthetic, the pupil dilates. When this latter condition occurs, measures to effect restoration must at once be instituted. However, the pupil also dilates during the emergence from chloroform-narcosis, and especially before nausea or vomiting ensues. To distinguish between these two conditions needs the utmost caution. In the latter, the patient will evince symptoms of returning consciousness; in the former, the condition of deep anæsthesia will persist, the pulse will be almost imperceptible, and the respiration will be hampered. When the dilatation of the pupil results from returning consciousness, the treatment is a fresh supply of chloroform, which will usually prevent vomiting and cause the pupils to return to their normal size.

When vomiting occurs in spite of all efforts to prevent it, especially when the stomach contains partially-digested food, the head must be turned aside and free egress given to the vomited matter. If necessary, the mouth must be cleansed with the finger covered with a napkin. The danger to be avoided in this emergency is the sucking backward into the larynx of vomited matter when the patient makes the strong inspiration which always follows emesis.

The color of the patient's face, lips, and ears, is a valuable guide: lividity, cyanosis, and pallor are indications that danger is present.

It should be borne in mind that operations on the rectum and on the vagina, even when the patient is fully under the influence of the anæsthetic, often, indeed generally, cause noisy, jerky respiration, so much resembling stertor that it is sometimes mistaken for it. Such respiration does not necessarily indicate an over-dose of the drug. The true condition of affairs can usually be determined by a little attention to the circumstances. Thus, the noisy breathing does not occur until the rectum and vagina are manipulated, and it is especially loud when the finger or instrument is passed with any force into either orifice (Ringer).

The operation completed, the patient must be carefully watched until he has recovered consciousness sufficiently to prevent accidents from vomiting, dropping back of the tongue, etc. Consciousness usually returns in a few minutes, but is sometimes delayed for a longer period.

If perfect quiet is observed, sleep ensues, which greatly refreshes the patient, gives time for many of the disagreeable consequences of the inhalation to pass off,—such as vomiting, headache, etc.,—and allows the pain of the operation to subside.

THE DANGERS AND ACCIDENTS ATTENDING THE ADMINISTRATION OF CHLOROFORM.

Respiration.—When any serious symptoms arise, and danger is imminent, the chloroform administration should, of course, be discontinued, and artificial

respiration, after Sylvester's method, practised instantly and assiduously, whether the breathing has ceased or is growing slower and shallower. Where the breathing has been extinguished in a gradual manner, the patient in most instances, provided artificial respiration is instantly adopted, in a few seconds gives a deep gasp, which is soon repeated, and presently the breathing grows more and more frequent till it becomes natural, and life is saved. In cases where the breathing and the pulse both cease immediately, without warning, little can be expected from the use of artificial respiration alone. In conjunction with it, hot and cold water should be dashed alternately on the front of the chest; the fingers of the anæsthetizer should be placed back of the angles of the inferior maxilla, which is pressed forward, thus carrying the tongue with it; the tongue should be seized and drawn forward; the head of the patient should be lowered; hypodermatics of strychnine may be given; and, finally, the diaphragm may be faradized, one pole being placed on the pit of the stomach and the other on the root of the neck.

As soon as swallowing returns, diffusible stimulants should be used, such as alcohol and ammonia.

Heart-failure, the most formidable accident of chloroform-narcosis, may be rendered manifest by the flickering or disappearance of the pulse, by characteristic pallor, sudden stoppage of the heart, blueness of the ears and finger-tips, sudden wide dilatation of

the pupils, and cessation of respiratory movements. There is little or no warning of the onset of this syncope, nor, according to Buxton, can the most careful preliminary examination give an indication of cases in which it is liable to occur. Persons who are subjects of fatty degeneration of the heart, or of aortic or advanced mitral disease, are, of course, always liable to heart-failure; but the robust and vigorous incur the same risk, and are frequently the victims of syncope occurring in the initial stage of chloroform-narcosis.

Decisive measures for resuscitation must be immediately instituted.

According to Dr. H. C. Wood,* ether, alcohol, ammonia, nitrite of amyl, atropine, and caffeine, by hypodermatic injection or by the mouth, are so uncertain in their effects as to be comparatively useless in time of imminent danger, such as is experienced from syncope.

The hypodermatic use of digitalis is strongly recommended by Dr. Wood, who in his series of experiments found that it produced a pronounced, persistent, gradual rise of the arterial pressure, with an increase in the size of the pulse-rate. In several instances Dr. Wood saw death apparently averted by its use, and in one or two cases, where large amounts of the drug had been employed, he witnessed a sud-

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* Medical News, *loc. cit.*

den systolic cardiac arrest, indicating that digitalis, if given in sufficient amount, is able to assert itself victoriously in opposition to chloroform. It is asserted by this high authority that in all cases of weak heart in man, a full dose of digitalis before the administration of chloroform would greatly lessen the danger of cardiac collapse.

The hypodermatic injection of strychnine in comparatively large doses (one-sixtieth to one-thirtieth of a grain), is also recommended by Dr. Wood (*loc. cit.*). He states that by its use a gradual rise of the arterial pressure is produced, and that the respiration is markedly increased.

Finally, he recommends the inversion of the patient briefly and repeatedly, and the use of forced respiration (by means of blowing air into the lungs).†

Among other measures advocated for counteracting heart-failure must be mentioned, though only to condemn, electrical stimulation of the heart, and acupuncture of that organ.

Occlusion of the throat by the falling back of the tongue is most easily obviated by pushing the lower jaw forward as far as its articulation will allow; or the tongue may be seized and drawn forward.

Mucus sometimes collects in the larynx and pharynx, and in a weak subject whose respiratory efforts are not vigorous, may cause suffocation. Care

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† See Dr. Wood's paper, Medical News, August 9, 1890.

upon the part of the administrator will prevent serious trouble from this cause.

Vomiting is most frequent when the inhalation takes place soon after a meal, but the best directions with regard to diet will not always prevent it, as food is sometimes undigested when the patient is anxiously expecting a surgical operation. The breakfast may be vomited in an unaltered state after the lapse of several hours. Moreover, there may be sickness and retching when there is nothing in the stomach. If bilious, plethoric persons have their bowels well cleared before taking chloroform, they are less liable to sickness (Buxton). To avoid this distressing act of emesis as far as possible, the patient's head should be kept quite low; he should not be moved from the operating-table for half an hour after coming to himself, and then the utmost care must be exercised to prevent undue shaking or raising of the head. It is desirable also not to give anything to eat or drink till about three hours after chloroforming. Opium should not be given by the mouth; and, unless there is urgent need, stimulants must be withheld.

Faintness and depression occasionally follow the administration of chloroform. The treatment for the condition is the horizontal position, with ammonia to the nostrils, and the internal use of wine or brandy if the faintness does not soon subside.

Hysterical symptoms sometimes come on in female patients as the effects of the chloroform are subsiding.

They require no specific treatment, and usually pass off spontaneously within several hours.

Albuminuria and Glycosuria of a transient and unimportant character may follow the use of chloroform.

Conditions which admit or contra-indicate the use of chloroform as an anæsthetic.—According to Ringer, there are no conditions of age or health which forbid the use of chloroform as an anæsthetic, provided due care be observed in its administration. Dr. Ringer has personally given the drug, without any threatening symptoms, in serious heart disease, in every stage of phthisis, in Bright's disease, in cancer, in chronic bronchitis, to patients almost dead of exhaustion from loss of blood, to children of a few weeks, and to persons close upon a hundred years old. He states that a fatty or dilated heart undoubtedly adds to the patient's risk, and enforces upon the operator more care and anxiety; and that the two extremes of age are conditions which exact close watching whilst administering chloroform.

In this country chloroform is employed only by the great majority of surgeons*, in those cases in which the other anæsthetics have failed, or in those exceptional operations, such as staphylorrhaphy, in which it is especially desirable to prevent coughing and the hypersecretion of bronchial and laryngeal

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* Anæsthetics, Medical and Surgical Reporter, March 9, 1889.

mucus. It is largely used in obstetric practice,† and is thought to be far safer when given to children than when employed with adults; but within the past year several deaths have been reported among the former class by Gibney, Sherman, and others; so that every precaution must be observed in the employment of chloroform, even in cases supposed to be most favorable.

The drug is contra-indicated in persons with weak hearts and of depressed vitality; and, in fact, it is not generally employed in America when any serious lesion exists in the heart, the lungs, or the kidneys.

What proportion does the number of deaths from chloroform bear to the whole number of those who inhale it, is a question that may be asked, in estimating the safety of this drug as compared with the other anæsthetic agents. Unfortunately, this question cannot be answered; for, while cases of such accident are generally published, the number who inhale the drug without injury is unknown.

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† For an account of its use in midwifery, see Chapter XI., "Artificial Anæsthesia in Obstetric Practice."

CHAPTER V.

NITROGEN MONOXIDE—NITROUS OXIDE—LAUGHING GAS.

Chemical and Physical Properties.—Nitrous oxide gas (N_2O) is a colorless substance, almost devoid of odor. It is a very active supporter of combustion. Water absorbs nearly its own bulk of it. At a pressure of fifty atmospheres and a temperature of 44.6° F. (17° C.) it becomes liquefied; and advantage is taken of this property to enable the gas to be carried about in iron bottles. As soon as the pressure is removed it assumes the gaseous state.

The propriety of storing the liquefied gas and keeping it for a length of time in this state has been questioned by many whose judgment is reliable, and who speak more favorably of the freshly-prepared substance as an inhalation.

In Philadelphia, the opinion of such men as Dr. Thomas and Dr. Samuel Kimmell, dentists of large experience in the use of this anæsthetic, is not unfavorable to the liquefied gas, of which they make use constantly in their practice. They have not found it less palatable or more prone to induce headache than the freshly-prepared gas.

Physiological Action of Nitrous Oxide.—According to Dr. H. C. Wood, when pure nitrous oxide gas is inhaled for from half a minute to three minutes, insensi-

bility is produced, preceded in many cases by decided evidences of excitement. Some persons under its influence will sink quietly away into unconsciousness, but others will become hilarious, erotic, or pugnacious, and be restrained only by force. During the stage of anæsthesia the patient presents the appearance of asphyxia.

It is probable that the paralysis of function invades the different portions of the nervous system in the same order as that caused by ether, but we have no positive knowledge upon the subject. It is well established that the gas is not capable of yielding oxygen so as to support life. A taper will burn in it, it is true, but the decomposition of the nitrous oxide is due to the high heat, and at the temperature of the body it is a stable compound.

This gas, when administered pure, enters the blood by diffusion through the thin walls of the air-cells of the lungs. In the blood a small quantity is dissolved, but the bulk is connected in some loose way with the blood-constituents, probably being associated more or less closely with the albumens and albuminoids of the liquor sanguinis and corpuscles (Buxton). The effect of shaking arterial blood with nitrous oxide gas is to darken the blood, showing that the gas is able to displace oxygen. Whatever union does take place is very unstable, as blood parts at once with its nitrous oxide when left in free contact with oxygen or air.

The respirations under nitrous oxide become slow and shallow, and if the gas be pushed, a complete cessation of the respiratory movements eventually will take place. The amount of tissue-change occurring in nitrous oxide narcosis is lessened, and so the quantity of carbonic dioxide which the lungs give off is diminished.

The heart beats quietly, fully, and regularly under the gas; the pulsations are somewhat slowed in profound narcosis. There is, however, but very slight danger of heart-failure resulting from its inhalation. In animals killed by nitrous oxide gas, the heart continues beating even after the respirations have ceased. It is therefore less important to watch the pulse than it is to watch the respiration.

The Muscular System.—There is suspension of muscular action, but no general muscular relaxation. The superficial reflexes are abolished; that of the patellar tendon, however, persists; and in many cases ankle clonus is developed under nitrous oxide.*

In the London *Lancet*, June 14, 1890, Dr. Silk is recorded as having reported to the Odontological Society notes on a series of one thousand cases in which this gas was administered and which had been carefully studied by the author.

In twelve per cent. there was more or less itch-

* See a paper by Dr. Dudley Buxton, on "Ankle-Clonus under Nitrous Oxide," British Medical Journal, September 25, 1887.

ing; in two per cent. asphyxial symptoms occurred, necessitating the pulling forward of the tongue; a number became hysterical; and several suffered after-effects; but seventy per cent., so far as known, had no trouble.

The average quantity of gas used was between four and five gallons, and the average time during which the face-piece was in position was sixty-seven and a half seconds. The duration of the anæsthesia was very variable, as it was exceedingly difficult to know when sensibility had returned; the absence of the conjunctival reflex, or the presence of jactitations, was no guide. In 467 cases pure gas was employed, either from the bottle of compressed gas or through a gasometer, and in 520 cases a supplemental bag, from which the gas was inhaled over and over again. Unpleasant effects immediately followed more frequently with pure gas than with the use of the supplemental bag, whereas the remote symptoms occurred in greater number after the use of the supplemental bag; but this was more apparent than real, owing to the smaller number of cases in which pure gas was used, and to the great difficulty of getting an authentic account of the after-history of the patient. Micturition occurred in ten cases, or one per cent.; all of these were females. In three of these there was opisthotonos, and in one much struggling. Erotic movements and sexual illusions were present in six cases,—all females; five of them were unmarried; one married and in the early stage of pregnancy.

It is probable that more or less headache followed the administration of the nitrous oxide gas, though it was found impossible to obtain a satisfactory record of the after-effects of the gas.

There was apparently no danger in giving the gas to epileptics. In one case of valvular disease of the heart, the patient had gas administered four times, the lividity following being more lasting than normal, and on one occasion a tendency to syncope ensued In nine cases of pregnancy nothing amiss occurred, except a tendency to vomit. In the only case of administration during lactation the patient had a bilious attack the next day, and the infant was somewhat sickened.

Inhalers and Accessory Appliances.—A properly-constructed inhaler is one of the most important adjuncts for the administration of this gas. Even with pure gas and a perfect receptacle, its use may be attended with serious difficulties, not to say fatal results, if the inhaler be faulty in principle or construction. The requisites of a good inhaler are, according to S. H. Guilford, D.D.S.,* that it be perfectly air-tight in its fittings; that it be of sufficient calibre to admit a full volume of gas (its area should be greater than that of the rima glottidis); that its valves be free in action and tight when closed; and that it be so formed as to fit the face perfectly. It should also be provided

* "Nitrous Oxide, its Properties, Method of Administration, and Effects," 1887.

with a simple yet accurate *cut-off*, to prevent the escape of gas at the close of the administration.

Any admixture of air occurring through imperfect application of the appliance or carelessness of the operator will either very much delay or wholly prevent the desired result. The calibre of the tubing and inhaler is also of great moment. It should be large enough at every point to permit the passage of a volume of gas sufficient for full and easy inhalation on the part of the patient. The lividity of the countenance, and especially of the lips and eyelids, so noticeable in the earlier days of gas-administration, was undoubtedly due to the fact that the patient received the gas at each inhalation in such limited quantity that partial asphyxiation took place before the anæsthetic stage was reached (Guilford). Since the introduction of improved inhalers of large calibre, this appearance of cyanosis has been almost entirely done away with. With the larger volume of gas available and the unlabored action of respiration, the full anæsthetic stage is reached before asphyxiation can take place.

The older inhalers were provided with a hard rubber mouth-piece. To prevent the inhalation of air in their use, the lips were held in contact with them by means of several fingers of both hands of the operator, while the nostrils were closed by the pressure of some of the remaining fingers. This method was not only uncomfortable as well as alarming to

the patient in consequence of the feeling of suffocation produced, but was also exceedingly inconvenient for the operator. The rubber hood now employed is a great improvement in every way, for, while it adapts itself readily to the contour of the face, covering both mouth and nose, and allowing inhalation through each, it leaves the hands of the operator free for his work.

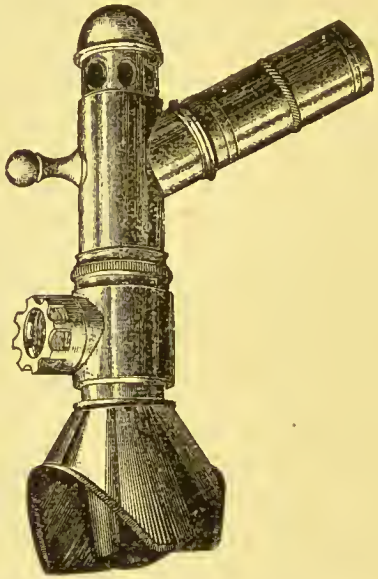

Fig. 5.

It has already been stated that the valves of an inhaler should be perfectly air-tight, so that the gas shall be administered free from any atmospheric air, one breath of which is sufficient to dilute two or more

breaths of the gas. If the valves fail in the proper performance of their functions, besides the disadvantage of having air admitted during inhalation, the exhaled nitrous oxide combined with carbonic acid gas will be forced back into the receiver, to be again inspired with the next inhalation.

The inhaler shown in Fig. 5 is the cleanest, most convenient, and most effective that can be used for the administration of nitrous oxide. It has an almost automatic action, and requires the use of but one hand, the inlet valve being opened by a slight pressure of the thumb, so that the gas can be turned on without the patient's knowledge.

Upon the removal of the pressure, the valve closes automatically and shuts off the gas.

This sectional view (Fig. 6) shows the internal construction. An opening, B, underneath the body of the inhaler, admits the gas through a similar opening, A, situated in a sliding tube, G G, fitted inside of, and projecting beyond, the rear portion of the main body. The projecting portion is perforated for the admission of air, and its outer end is closed by a cap. At the inner end of the sliding tube is a coiled spring, E E, abutting against a shoulder in the body of the inhaler. This spring holds the sliding tube in the position shown in the cuts, closing the inlet B when the gas is not in use. Pressure on the cap compresses the spring, closes the perforations for the admission of air, and brings the opening A over B,

affording a free flow of gas to the mouth-piece through the inhaling valve. The sliding tube is prevented from rotating by the screw-pin D, which works in a slot, C. The inhaling and exhaling valves—the former internal, the latter external—consist of two thin disks of mica, F F, which are enclosed in circular open cages.

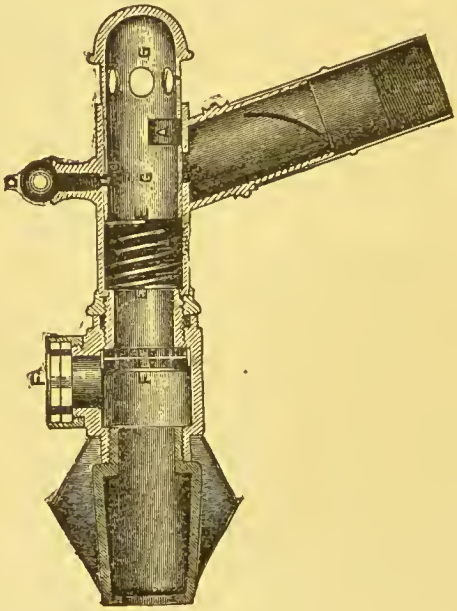

Fig. 6.

The inhaling valve is opened in respiration by being drawn against the front of the cage, the exhaling valve being closed by the pressure of the outside air. In expiration both disks are thrown against the farther

end of the cages, opening the exhaling and closing the inhaling valve.

The entire inhaler, except the mouth-piece and the two valve-disks, is of metal, smoothly finished, the outside polished and nickel-plated. It is readily taken apart for cleaning.

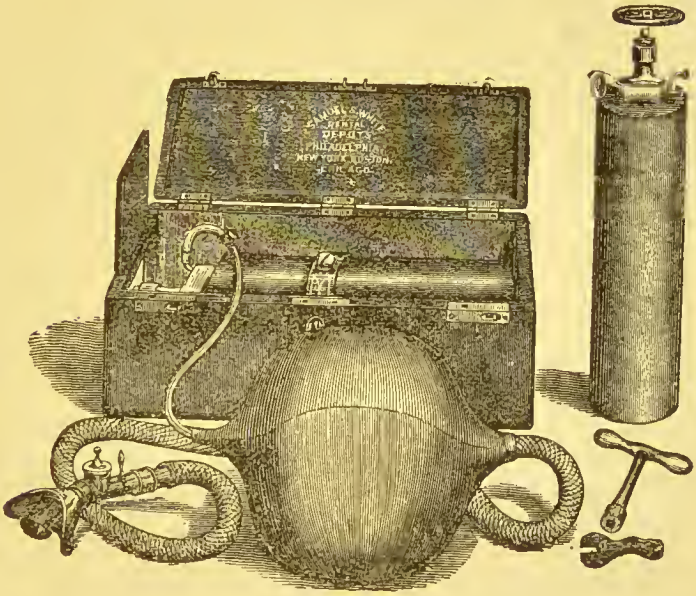

Fig. 7.

A most complete apparatus for the surgeon or dentist for the administration of the liquefied gas, to which is attached the necessary tubing, with gas-bag and inhaler, the whole being enclosed in a stout leather-covered case lined with velvet, is shown in Fig. 7.

Gags or mouth-props are indispensable adjuncts in the administration of nitrous oxide gas, for with this drug more than with any other is it necessary to keep the jaws apart, especially in the extraction of teeth. According to Dr. Guilford (*loc. cit.*), gags, to be efficient and safe, should possess the following properties. They should be strong and indestructible; they should be easy to cleanse, hence non-absorbent; they should keep their place and not slip; they should be sufficiently elastic to prevent injury to frail teeth; they should be large enough to be incapable of being swallowed, or should be protected with a strong twine.

Gags made from large bottle-corks cut to shape have been used, but they are dangerous, owing to their ready destructibility and to the possibility of portions of them finding lodgment in the trachea. In addition, being absorbent, they are unclean. This last objection holds equally good in reference to gags made of wood or of felt. A gag devised by Dr. Guilford, made of partially vulcanized rubber such as is used for car-springs and carriage-buffers, has met with much professional favor. The material can be bought in bulk at the rubber-stores and cut to the required shape and afterwards made smooth with a knife and a vulcanite file. The two transverse diameters are nearly equal. The two sides presenting respectively to the tongue and the cheek are flat, while each of the other four sides is concave. These

concave surfaces are to accommodate the teeth or the alveolar ridges and by their shape prevent lateral slipping. Various sizes of these gags may be made, varying from three-fourths to one and three-eighths inches. They can be readily cleansed, are indestructible, and, while the teeth may partially compress them, they are incapable of injuring the frailest teeth.

Methods of Administering Nitrous Oxide Gas. — In producing anæsthesia by this agent, it should be borne in mind that it is to be given pure, without any admixture of air. It must also be remembered that it is never safe to give this or any other anæsthetic substance except in the presence of an intelligent male or female assistant. Artificial teeth must be removed, and if the patient is very old and feeble, or if there are diseased lungs, or a fatty heart, the reclining posture is the safest. The ordinary posture is the sitting or half-reclining. Ladies should be instructed to loosen their dress or stays if they be at all tight, so as to give full play to the organs of respiration. It is of the utmost importance that absolute silence be observed by every one present during the administration. The patient is now to be reassured by a few cheering words and directed to breathe freely. It is well to allow a nervous subject to take several very deep inspirations before applying the face-piece, as these clear the lungs and divert attention from the natural dread of the operation.

The operator stands on one side, and carefully

introduces between the teeth a gag, to which is attached a string as a precautionary measure against its falling backward into the pharynx. The gas should now be drawn from the cylinder into the intermediate bag or gasometer, after which the face-piece or hood of the inhaler should be adapted to the face of the patient and he be directed to breathe. For a few seconds, or until he has become accustomed to the instrument and acquired the proper manner of respiration, the patient should be allowed to breathe only the air through the exhaling valve. When confidence has thus been inspired, the inhaling valve should be opened, gently and continuously, and the gas administered. After the first fifteen or twenty seconds,—that is, after the lungs are presumably filled with nitrous oxide, and when gas is gaining tension in the blood,—lividity of the skin appears, and the ears and finger-tips darken, consciousness, however, being fully present for ten or fifteen seconds longer. In half a minute the patient's power of receiving impressions is markedly blunted, and in a few seconds additional, consciousness is completely lost. At this stage, loud noises, rough handling of the patient, and the like, may lead to a complete regaining of consciousness. In from forty-five seconds to a minute, the pupils will dilate, the eyes becoming dull and expressionless, and there may be strabismus. The conjunctival reflex will persist, and if the face-piece be removed at this stage the return to conscious-

ness will be rapid. There is usually time at this stage for the extraction of one tooth, if fairly loose, but not of more; or an abscess may be opened, etc. When the inhalation is not checked at this time, further signs of deeper anæsthesia appear. In about a minute and a quarter, the breathing grows stertorous, muscular movements of the hands and feet supervene, and the conjunctival reflex is lost. The eyeballs begin to oscillate, and if the gas be still inhaled the breathing becomes slowed and intermittent. *According to Clover, should it cease for more than fifteen seconds, air must at once be given. At this period of deep anæsthesia there is great stress imposed upon the heart, so that the pulse should be watched, and if it flag, the administration should be at once discontinued.* The patient is now ready for operation, and it is not wise to attempt to push the nitrous oxide to a greater extent.

According to Guilford (*loc. cit.*), complete anæsthesia from this gas may be recognized by the following indications:

1. If lividity of the lips and eyelids is noticed, unconsciousness is near at hand, and to carry the administration much farther would be hazardous.

2. When the snoring (*which is not to be confounded with the stertor preceding death*) becomes marked, it affords an infallible sign that the full anæsthetic stage is reached.

3. The hand or finger being passed rapidly before the open eye of the patient, without touching it,

the non-closure of the eyelid will indicate that unconsciousness is complete.

The first two indications are the most reliable and readily discernible, but if they leave us in doubt the third will aid materially in deciding when the administration should cease.

It is important to recognize the signs of returning consciousness, so as to know when to desist from further operative measures. In the first place, the normal color of the face returns, and the lips change from their ashen hue to a natural crimson. The patient commonly moves a limb or utters a cry, though not one which implies consciousness; frequently restless movements of the body occur. The time which elapses between the removal of the face-piece and the period of recovery to consciousness varies somewhat; it is usually a minute, but may be as short as thirty seconds; or, on the other hand, it may be prolonged ninety seconds.

After-Effects from the Administration of Nitrous Oxide.—Fortunately, the administration of this gas is seldom followed by any after-effects, and such as are encountered are not of a serious nature. Hysterical men and women may laugh and cry and work themselves up to a pitch of excitement, which often is attributed to the anæsthetic; epileptics occasionally have a fit during the exhibition of the gas or immediately afterwards. Nausea will occasionally occur after recovery, but when it does it is usually due to

extreme sensitiveness of the stomach or to the accidental swallowing of blood. The vomiting may be lessened or prevented altogether by the administration of a little brandy-and-water, and by affording the patient plenty of fresh air.

Among a few persons of a peculiar temperament, certain nervous symptoms have been known to follow. Thus, severe headache is sometimes occasioned, while cases are reported where hemiplegia, paresis, or hallucinations are said to have ensued. Syncope sometimes, though rarely, ensues. It is usually due to a predisposition to the ailment, or to excessive weakness of the patient from some constitutional cause.

Accidents and Emergencies following the Administration of Nitrous Oxide Gas.—The possibility of accidents occurring or of emergencies arising in connection with the administration of any anæsthetic must ever be kept in mind, and the means of meeting them must be always at hand.

The most common danger associated with the administration of nitrous oxide is that arising from a spasm of the muscles leading from the base of the tongue to the hyoid bone and pharynx, producing a condition which is graphically described as "swallowing the tongue." This sometimes occurs with great suddenness, and, if unrelieved, threatens death from asphyxia. The tongue should, of course, be immediately drawn forward by forceps, and held there by forward pressure behind the angles of the jaws until

the spasm disappears or the patient recovers consciousness. In cases of extensive heart disease the danger of fatal syncope should be borne in mind, and similarly the risk of asphyxia should be remembered in cases with grave pulmonary troubles. Accidents of a minor character are liable to occur, usually through the lodgment of some foreign body in the larynx during the unconsciousness of the patient. Thus, the broken beak of a forceps, the whole or part of a mouth-gag, or a tooth or portion of one, may easily be drawn into the trachea unless due care is exercised by the operator. The dangers of such casualties are *immediate*, from asphyxia due to laryngeal spasm excited by the foreign body becoming entangled in the larynx; and *secondary*, from the foreign body working down into the bifurcation of the trachea and there developing pulmonary trouble.

To avoid such accidents, all instruments used for the mouth should be carefully examined for flaws, and all gags, props, etc., be secured by some strong, cleanly material attached outside the mouth. A root or other portion of a tooth may at times slip back into the fauces and be drawn into the trachea in spite of the greatest precautions; but every means should be adopted to prevent such an occurrence.

If the impairment of respiration be not serious, we may wait for a time for nature to expel the body; but if the danger be imminent, the position of the obstacle should be located as nearly as possible, and tracheotomy performed.

An accident of minor importance, resulting in discomfort rather than danger, is luxation of the inferior maxilla. Sometimes through the looseness of the condyloid articulation, and sometimes through excessive force applied in the extraction of a tooth, the jaw becomes dislocated. Should this occur, reduction is readily accomplished by placing one's thumb, properly protected with a napkin, between the teeth, as far back as possible, and then pressing the chin upward and backward, by which manipulation the condyles of the jaw are released from their malposition and caused to slip back into their proper place.

The Dangers of Nitrous Oxide to Particular Classes of Cases.—In *heart disease* the tendency to syncope is increased by the administration of this gas, but this is not a contra-indication for giving this anæsthetic. True, if the operation in such a case can be done without any anæsthetic agent, it would be just as well to dispense with such an agent; otherwise, with due carefulness upon the part of the operator, the gas should be employed.

Age of itself offers no serious objection to the employment of nitrous oxide, patients over ninety having taken it successfully (Buxton).

In *extensive pulmonary disease*, especially in phthisis, when hemorrhage is known to have occurred the gas should be administered with extreme caution, as there is danger of starting fresh bleeding.

In *pregnancy*, care must be exercised in giving this gas, especially if the patient be within a short period of her accouchement, as the nervous system is peculiarly liable in such cases to receive strong impressions, and is easily thrown off its balance.

In these cases the question must always be weighed as to whether the surgical procedure without any anæsthetic is more liable to jeopardize the patient's welfare is than the giving of an anæsthetic.

As an anæsthetic, nitrous oxide is chiefly valuable when short, minor operations are to be performed. The rapidity with which insensibility is induced and with which consciousness returns, and the general absence of after-effects, tend to make the employment of this gas very popular for such cases, as we have already indicated. It has never, however, become popular with surgeons.

Diabetes mellitus, chlorosis, epileptic symptoms, and albuminuria have been said to follow the use of nitrous oxide gas.

CHAPTER VI.

LESS COMMONLY USED GENERAL ANÆSTHETIC SUBSTANCES.

ALCOHOL.

Alcohol (C_2H_6O) might be conveniently grouped as an anæsthetic with chloroform and ether, there being much similarity in the action of these three substances. Each, at first, produces excitement, with increased strength of the pulse, this stage after a time giving way to a stage of unconsciousness, which may be profound; but, as stated by Ringer, with this general similarity there is an important difference between alcohol on the one hand and chloroform and ether on the other. With the two last-named drugs the stage of excitement is brief, soon passing into the stage of insensibility, which may continue a long time without danger to life. But with alcohol the early stage of excitement and intoxication is of considerable duration, insensibility and unconsciousness not coming on until large quantities have been taken and till some time has passed. In this stage of insensibility the danger of death is imminent from paralysis of the heart and of the movements of respiration. It will be readily understood, therefore, that the use of alcohol for anæsthetic purposes is inadmissible.

AMYLENE.

Amylene (C_5H_{10}) is a volatile and inflammable ethereal fluid, of an unpleasant odor resembling that of cabbage. It was discovered by Balard in 1844. It is very sparingly soluble in water, but fully soluble in alcohol and ether. It is prepared by heating amylic alcohol with a concentrated zinc chloride solution to 266° F., being then distilled from a water-bath over caustic potash, and afterwards rectified. It was experimented with by Snow, in 1856, as an anæsthetic, and proved very powerful as such, acting very much like chloroform; but, proving also capable of killing (two deaths occurring in Snow's practice), it never met with professional favor.

BROMOFORM.

Bromoform ($CHBr_3$) is a heavy, colorless liquid, volatile, of a sharp ethereal odor and a rather sweetish taste. It dissolves sparingly in cold water, but readily in warm water and in ether. According to the researches of Bonome and Mazza, this substance acts as a general anæsthetic both upon man and upon the lower animals, causing, however, much irritation of the conjunctiva and the nasal mucous membrane. The experiments of Dr. E. T. Reichert proved it to be a powerful cardiac depressant, and in his opinion it possesses but little value as a practical anæsthetic.

ETHYDENE CHLORIDE.

Ethydene Chloride (Ethydene Dichloride, $CH_3.CH\ Cl_2$) is an ethereal body, isomeric with and much resembling ethylene dichloride. It was first used as an anæsthetic by Snow, and later was employed by Liebreich, Langenbeck, the British Anæsthetic Committee, Clover, Bird, Hodges, and others.

Upon the human subject, according to Buxton, this drug exercises the following effects. At first a pleasurable glow diffuses itself over the whole body; then within a minute or two the senses are confused, and often singing or whistling is induced. Some muscular rigidity then appears, and anæsthesia follows. It takes a longer time for patients to recover consciousness than when chloroform is used, but they experience fewer after-effects.

According to Prof. E. T. Reichert, the two chief dangers attending the use of this drug are its likelihood—1, to cause sudden death (acting at times entirely out of proportion to the magnitude of the dose); 2, to cause death by failure of the respiration. Dr. Reichert states that the record, up to the present time, shows an average of one death for each thousand administrations, with many cases in which very alarming symptoms ensued and the patient was rescued from death only by the most active and persistent treatment; he asserts that the drug "is unquestionably a dangerous anæsthetic, and, since it is likely

to cause sudden death by failure of the circulation, some circulatory stimulant should be at hand during its use."

ETHYLIC BROMIDE.

Ethylic Bromide (Hydrobromic Ether, C_2H_5Br.) is a colorless, neutral liquid, of an ethereal odor and a disagreeably sweetish taste, dissolving sparingly in water, but freely in alcohol and in ether. It affects the human system very similarly to chloroform, producing profound anæsthesia rapidly and pleasantly. Its effects pass off very quickly. Both the circulation and the respiration are profoundly influenced by its depressing action. A few years ago it was strongly advocated by Dr. R. J. Levis, Dr. J. J. Chisolm, and others, as an anæsthetic meeting the long-sought desideratum of possessing agreeableness of effect, combined with rapidity and safety of action; but, in the extended observations that followed, several deaths occurred from heart-failure. It is administered similarly to chloroform, but, from the excessive volatility of the liquid, it requires almost total exclusion of air during inhalation. Owing to its instability, it is liable to become contaminated with carbon bromide and free bromine, and great irritation may ensue from inhalation of these impurities. This fact, in conjunction with the deaths occasioned by its use, has led to the almost total abandonment of the drug as a general anæsthetic.

METHYLENE BICHLORIDE.

Methylene Bichloride (CH_2Cl_3) is a colorless, volatile liquid, with a smell like that of chloroform. It was first introduced to the notice of the profession by Dr. B. W. Richardson, as an anæsthetic similar to, but more pleasant and possibly safer than, chloroform. It has been used to a considerable extent in certain London hospitals. The most earnest advocate for the use of this drug was Sir Spencer Wells, who believed that with this agent he had all the advantages of complete anæsthesia, with fewer drawbacks than from any other. It has been employed extensively in this country. Several deaths from syncope have occurred from its use; and this fact, with the great care necessary to be observed in its employment, has shaken the confidence of some of its early friends as to its value.

CHAPTER VII.

ANÆSTHETIC MIXTURES.

The dangers of cardiac syncope and of respiratory paralysis, which attend the use of chloroform and the stronger anæsthetics, have occasioned the use of various admixtures of these drugs, in the hope of diminishing the perils attending their individual use.

These substances are aptly divided by Dr. Dudley Buxton (*loc. cit.*) into two classes: *1. Admixtures of members of the alcoholic or ethereal series. 2. Admixtures of alcoholic or ethereal anæsthetics with alkaloids or other bodies.*

The principal members of the first division of this group are—

The A. C. E. Mixture.—One part of alcohol (sp. gr. .838), two parts of chloroform (sp. gr. 1.497), and three parts of ether (sp. gr. .735).

Billroth's Mixture.—Three parts of chloroform and one part each of sulphuric acid and alcohol.

Linhart's Mixture.—One part of alcohol and four parts of chloroform.

The Vienna Mixture.—One part of chloroform and three parts of ether.

The A. C. E. Mixture was originally proposed by Dr. George Harley, and received the strong endorsement of the Anæsthetic Committee of the Royal

Medico-Chirurgical Society of London. This Committee preferred the A. C. E. Mixture to the various admixtures of chloroform and ether because, in their opinion, the combination of the alcohol rendered possible a more uniform blending of the ether and chloroform, and probably the more equable escape of the constituents in vapor. This mixture has been largely used in England, and occasionally in America, and is deemed by competent authority an excellent substitute in many cases where ether cannot be taken. The main objection to the employment of this and all other mixtures is the unequal rate of vaporization of the various fluids of which they are composed, which renders it impossible to be sure what percentage of vapor of chloroform is being inhaled. A greater length of time is also required for the production of complete anæsthesia, and there is more attendant excitement, when the mixed fluids are employed, than under the use of ether and chloroform alone.

The administration of this mixture is similar to that of either ether or chloroform, but its effects must be watched as closely as when chloroform is given alone, and there must be the same careful observance that plenty of air is allowed the patient.

The same sequelæ follow its use as follow the administration of chloroform or ether. Several deaths have occurred during the use of this mixture.

Billroth's Mixture is open to the objection that, containing a high percentage of chloroform, its admin-

istration is attended with all the danger accompanying the use of that drug alone. Several deaths have resulted from its employment. It should be given either by the open method, or by one of the various forms of inhalers.

Linhart's Mixture is of almost similar composition to Billroth's, containing one part more of chloroform and no ether. It is therefore subject to the same objection as the preceding admixture.

The Vienna Mixture possesses the advantage over the others mentioned, of containing a greater amount of the safer anæsthetic, ether. It is stated by Dr. Buxton to have been used eight thousand times without a casualty.

In America little reliance is placed upon any of these mixed vapors, they being deemed superior in no particular to ether alone.

Among the second group of anæsthetic mixtures may be mentioned—

Chloroform with Amylic Nitrite.—This has been employed by several American physicians.

In the *Medical Record*, October 5, 1878, Dr. George E. Sanford has recorded his experience with this mixture. He used two drachms of amyl nitrite to the pound of chloroform, and administered its vapor in the ordinary way of administering the latter drug. By this method the action of the heart was sustained and the pulse remained good.

Prolonged anæsthesia by this method cannot be

recommended, for amylic nitrite is a depressing poison, and the addition of its effects to those of chloroform might easily produce disastrous results. Again, the difference between the specific gravities of the two liquids—1.499 and 0.877—renders a permanent mixture out of the question. It therefore seems to us that the use of this mixture, which may be resorted to in brief operative procedures, can never lessen the dangers and consequent mortality of chloroform administration, and that it is in protracted operations that the depressant action of the drug is to be most feared.

Chloroform and Chloral.—Forné states that the administration of chloral hydrate in connection with the inhalation of chloroform produces an effect upon the patient very analogous to that produced by the combination of morphine and chloroform.

Perrin (quoted by Buxton) is said to have used as large a dose of chloral as forty-five grains before chloroforming.

The dangers which attend the use of this preliminary giving of chloral before the anæsthetic more than counterbalance any good effect it might exert.

Chloroform and Morphine.—This mixture was first used for anæsthetic purposes almost simultaneously by Nussbaum and by Bernard. Given hypodermatically to the amount of from one-sixth to one-third of a grain some forty minutes before the inhalation of chloroform, it is said to diminish the stage

of excitement, and to lessen by one-half, or even more, the amount of the anæsthetic required; the patient is usually more relaxed, the breathing is quieter, and it promotes quiet sleep afterwards.

Drunkards, and persons who show little susceptibility to chloroform, soon pass under its influence after a dose of morphine (Buxton).

Nausea and vomiting may ensue from the use of the narcotic.

In cases where great dread of the operation exists, giving rise to a state of excitement which experience has shown to have played no unimportant part in causing chloroform accident, this mixture is especially useful. Soothed by the narcotic, the patient passes tranquilly into the anæsthetic state, and appears to escape risks which otherwise would be encountered, judging from the comparative observations published of the same series of operations without and with the use of a preceding injection of morphine.*

In our opinion, whenever a hypodermatic injection of morphine precedes an anæsthetic, atropine should be added (see chapter ii., p. 12). It is a reliable cardiac respiratory stimulant, besides having a paralyzing influence upon the vagus, thus preventing the reflex inhibition of the heart by the anæsthetic through the par vagum.

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* Recherches sur l'anesthésie chirurgicale obtenue par l'action combinée de la morphine et du chloroforme, par H. de Brinon, Paris, 1878; Kappeler, pp. 202–209.

Ether and Chloral Hydrate.—Kappeler has used chloral hydrate in forty-grain doses before the administration of ether. Children should receive not over half this amount. His experiments extended to seventy cases. The character of the anæsthesia produced by ether under these circumstances was not materially altered. The principal difference consisted in the longer duration of insensibility and the more lingering recovery of consciousness. Vomiting occurred in twenty-nine cases.

One death has resulted from this mode of inducing anæsthesia, and there seems to be but little to recommend its use.

Ether and Nitrous Oxide Gas.—For long-continued operations this combination is one of the best. The plan adopted by Clover consists in the rapid induction of anæsthesia by the nitrous oxide, and the maintenance of this insensibility by the use of the vapor of ether. By this means, it is thought, the initial stage of excitement which sometimes follows the commencement of ether-inhalation is avoided. The time necessary for the production of anæsthesia is thus considerably shortened, and the requisite quantity of ether is lessened.

Clover's Gas and Ether Apparatus enables one to regulate the supply of gas or ether with an exactness unattainable by the use of any other instrument. The bulk of the apparatus, however, tends to restrict its use within comparatively narrow limits.

The explosive character of these combined vapors should not be forgotten.

Ether and Morphine.—The effect of morphine hypodermatically used upon animals previous to the administration of ether, according to Claude Bernard, is to prolong and render more tempestuous the period of excitement. Kappeler, who has experimented upon twenty-five patients, injecting one-fifth of a grain of the narcotic, states that he completely failed in several cases in which he attempted to narcotize patients by this method. However, some authorities speak highly of the procedure, and until the method has received further attention it would not be just to condemn it *in toto*. When morphine is employed it should be used in conjunction with atropine.

CHAPTER VIII.

LOCAL ANÆSTHETIC SUBSTANCES—COCAINE.

Cocaine ($C_{17}H_{21}NO_4$) is an alkaloid obtained from the leaves of *Erythroxylon Coca*, a plant which grows wild on the eastern slope of the Andes, in Peru, Bolivia, and Chili. The natives of these regions chew the leaves with quicklime, and are said to be thus enabled to work or travel a long time without food and without feeling exhaustion or fatigue.

Cocaine is a crystallizable substance. It is of a bitterish taste, soon benumbing the nerves of the tongue and depriving it of feeling and taste. Its reaction is strongly alkaline.

In 1855, Gaedeke discovered in coca this alkaloid, to which he gave the name of *Erythroxyline;* but this principle was first thoroughly studied by Dr. Albert Niemann, from whom it received the name *Cocaine*, by which it is now generally known.

Cocaine itself is very unstable, the simple contact of the free base with water being sufficient to decompose it. The *hydrochlorate of cocaine* is much more stable, and is the salt usually employed in medicine, especially for anæsthetic purposes.

Aqueous solutions of this salt should not be kept any great length of time, as they are liable to become contaminated by the growth of a fungus which exerts deleterious effects upon the patient. Various sub-

stances have been proposed as an ingredient of cocaine solutions, to prevent this fungoid growth, with varying measure of success, the principal of these being boracic acid, carbolic acid, camphor-water, and chloroform. The authors have frequently used a solution of this salt prepared with the addition of boracic acid (made from a preparation of Parke, Davis & Co.), which at the end of two months was, to all appearances and in its action, as fresh as when first put up.

Physiological Action of Cocaine.—This drug is a *cerebral stimulant*, producing a peculiar mental excitement, ending after large toxic doses in narcosis, with epileptiform convulsions, which are probably of cerebral origin. In the poisoning there is at first increased reflex activity, followed by paralysis of voluntary motion and of reflex activity, which effects are chiefly due to a direct action upon the spinal cord, the sensory side of the cord being probably more sensitive to the drug than the motor side. Toxic doses depress and finally paralyze the sensory nerves, and, though in a much lower degree, the motor nerves. The action of the drug upon the *circulation* has not as yet been well made out, but it is probably entirely subordinate to its influence upon the nervous system. According to several observers, the drug is a cardiac stimulant, increasing the power of the systolic contractions, and finally arresting the heart in systole; but other investigators have found it to produce diastolic arrest, even.

in the isolated heart. Moderate doses cause a rise in the arterial pressure, whether by interfering with respiration or by direct action is at present uncertain. Upon *striated muscles* cocaine appears to have a peculiar though very feeble action, which is not manifested during its poisoning.

It has been asserted that this drug acts as a powerful *diuretic*, but the drift of present evidence goes to show that it has no definite influence upon the amount of urine secreted; what evidence is available indicates that it decreases the elimination of urea. Upon the *eye* cocaine acts as an energetic mydriatic. It is a powerful stimulant to the *respiratory centres*, increasing the rapidity and fulness of the respirations, but, if the dose be sufficiently large, after a time it causes the respirations to become very shallow, and finally paralyzes the respiratory centres. Moderate doses are said to increase *peristalsis*, large doses to paralyze it.

Local Action of Cocaine.—Applied locally, this drug benumbs the nerve-filaments, and if sufficiently concentrated renders them completely devoid of sensation. Applied to mucous surfaces, or injected into the tissues, the effect is the same,—anæsthesia of the part; upon the tongue it causes a suspension of taste; upon the larynx its effect is such that the vocal cords may be touched without pain; its use upon the pharynx enables the patient to submit quietly to prolonged and painful laryngoscopy; applied to the eye,

it produces such a degree of anæsthesia that the conjunctiva may be cut or rubbed without sensation on the part of the patient. This action of cocaine locally applied was noted so long ago as 1862, but it was not until September, 1884 (*Wien. Med. Wochenschrift*, November, 1884), that Dr. Carl Köller, of Vienna, demonstrated the practical value of the drug. Since that time medical literature has teemed with contributions relating to the efficiency of cocaine as an anæsthetic.

Methods of Administration.—Applied to *cutaneous surfaces*, cocaine, even in strong solution (20 per cent.), exerts but little anæsthetic influence, its effects not extending farther than the true skin, since the dermis will not allow it to pass to the deeper structures. In *skin diseases*, a two-per-cent. solution used several times daily allays the itching in acute and subacute eczema, according to Lustgarten, being especially valuable in eczema of the anus and the genital organs of both sexes. In the form of an ointment, he employs the oleate of cocaine, from six to fifteen grains, and lanoline, four and one-half drachms, followed by the use of some dry dusting powder. In pruritus of the anus or of the genitals, it is a useful remedy in relieving the distressing itching induced by the complaint; it is employed either in the form of an ointment or by suppository. In freshly *abraded and painful surfaces*, such as scrapes of the skin, and recent burns with blistered or raw surfaces

(except when the burns are extensive, in which case toxic symptoms would be liable to be induced by absorption of the drug), painting with a two-per-cent. solution may give complete relief from pain.

Many *minor surgical operations* can be performed without pain by injecting cocaine hypodermatically and restraining the circulation by pressure, as advised by Dr. J. Leonard Corning, of New York City.

We have thus used cocaine in a very large number of cases of amputation of fingers and of toes, the avulsion of ingrowing toe-nails, the opening of abscesses and felons, the removal of nasal polypi, etc. The method we pursue for amputating fingers or toes, and for the avulsion of toe-nails, is as follows : The solution used consists of twenty grains of cocaine hydrochlorate and of ten grains of boracic acid to the ounce of distilled water. Having prepared the part for operation in a thoroughly antiseptic manner, the finger or toe is firmly constricted with a piece of rubber tubing. The hypodermatic punctures are then made, and the solution of cocaine is injected in three or four places about the locality at which the amputation is to be done. Usually from twenty to thirty minims are required. Insensibility supervenes in two minutes, or less.

When the amputation is done for a crush of the extremity, we usually inject one or two points in the soft parts, through the wound, and finally, as a test of the anæsthesia produced, run the needle through the

skin. In operations for the avulsion of ingrowing nails, the solution is first injected at various points around the nail, and then beneath it (the most sensitive portion). By this means a very good indication of the effects of the drug is obtained, and operative procedures can be gauged accordingly.

When the operation is finished, but before the sutures are applied, the band is loosened for a few moments, which restores the circulation, and allows the wound to bleed freely, thus giving escape to any excess of cocaine; of course a certain amount is carried into the general circulation. The ligature is now again tightened until the sutures are inserted.

Undoubtedly the elastic ligature used in these cases renders the part, to some extent at least, insensible to pain.

Another point of considerable importance in using cocaine hypodermically is to make use of a perfectly aseptic syringe; frequently, in cases where the drug is so used and suppuration follows, it is the fault of want of cleanliness in this particular, and not of the employment of the drug.

A four per cent. solution is as strong as need be used for hypodermatic injections. The principal advantages in using a solution of no greater strength are, that the anæsthetic property of cocaine can be made to reach to a larger area with a less amount of the drug than is the case when a more concentrated one is employed; and, furthermore, the dilution of the

drug renders it less liable to produce toxic symptoms.

When the circulation cannot be controlled, extreme caution must be observed in the use of the drug; especially is this the case when any considerable quantity is required.

In anal work, cocaine is not of much use as a local anæsthetic; when so used it must be employed cautiously. It is of no use in obtunding the pain of fistulous tract or of fistulæ *in ano*. Toxic symptoms are apt to ensue when the drug is employed in this region. The rich lymphatic and vascular supply of the part probably accounts for this fact.

For the purpose of controlling the circulation, a piece of elastic tubing is to be preferred to a solid ligature, as less damage is done to the soft tissues and more uniform constriction of the part is obtained.

In amputation of fingers and toes for injury, less pain is occasioned the patient if the primary injections are made through the wound, reserving the punctures through the skin until a later period, when the sensitiveness of this structure may be made use of in determining the degree of anæsthesia produced.

The quantity of cocaine required to produce anæsthesia varies with the operation and its extent; as a rule, for ordinary minor operations, from twenty-five to forty minims of a four per cent. solution are needed. The length of time necessary for the produc-

tion of local insensibility under cocaine varies from three to ten minutes.

Individual susceptibility to the toxic influence of cocaine is a complication of sufficiently frequent occurrence to surround the use of the drug with due care and caution, but it is not a contraindication to the employment of the agent as an anæsthetic. Untoward effects may arise from the use of any one of the anæsthetic substances.

Another objection urged by some surgeons to the employment of cocaine for anæsthetic purposes is based on its asserted power of inducing the so-called "cocaine habit." As yet, this influence of the drug is extremely rare. It is most liable to occur among the patients who are informed of the nature of the remedy used, and especially is this the case when it is employed internally for medicinal purposes. We hardly believe that this action of cocaine can be produced when it is employed for its local anæsthetic effect and in the small quantity needed to induce local insensibility.

2. *In genito-urinary surgery*, cocaine is to be used with more than ordinary care, as it is in this class of cases that the untoward effects of the drug have been most frequently noted. It has been employed successfully to allay excessive irritability of the urethra before the passage of sounds or of bougies: it is important, in such instances, not to allow the solution to remain in contact with the mucous surface more than

a few moments, and to subsequently encourage the outflow of any excess.

In the operation for circumcision, the anæsthetic action of the drug is prompt and efficacious, but it is important to remember that the circulation must be controlled before the injections are made, and that after the foreskin is removed and the sutures inserted, but not tied, that the ligature employed to regulate the blood-supply is removed and free bleeding allowed, that as much of the drug as possible may be washed out of the system.

For the purpose of preventing the pain incident to the removal of venereal warts, or in the cauterization of venereal sores the drug is satisfactory.

For the production of anæsthesia, previous to the operation of internal urethrotomy, opinions differ as to its efficacy and as to the danger involved of producing the toxic effects of the drug. The weight of evidence seems to prove that cocaine is not to be employed indiscriminately in these cases, and when used should be administered with caution and with a knowledge of the possible risks involved.

3. *In gynæcological practice*, the drug has a limited field of usefulness. As a rule, in operative procedures classed under this head, general anæsthesia is to be preferred, as the patient's knowledge of the exposure of her person is often quite sufficient to unnerve her for the operation, and may even be the means of frustrating the surgeon's work.

For slight operations and those easy of performance, such as the extirpation of vascular vegetations at the mouth of the meatus urinarius, the removal of stitches from the vagina, etc., anæsthesia from cocaine is all-sufficient. For the vaginal examination of highly nervous and hyperæsthetic women, cocaine, applied to the orifice of the canal, will render comparatively easy an otherwise difficult operation. For the primary repair of the perineum, when an anæsthetic is indicated, a dossil of cotton saturated with a solution of the drug and placed in the wound will accomplish the desired purpose.

4. *For ophthalmological work*, the surgeon finds in cocaine the anæsthetic *par excellence*. In no other department of surgery do we find its use so widespread and its application so entirely satisfactory. While this is true, it must be remembered that to obtain the best results it is more essential here than elsewhere to employ a perfectly pure drug in a freshly-prepared solution. Many of the untoward effects ascribed to the use of cocaine in eye surgery are due undoubtedly to the neglect of these two essential points.

All of the operations upon the eyeball may be performed under cocaine anæsthesia, except iridectomy for acute glaucoma, and enucleation. Even in the latter instance, according to Dr. Albert G. Heyl, where the patient does not come under the influence of the general anæsthetic, or when it is desirable to

shorten the duration of the operation, the instillation of a solution of cocaine enables one to begin it earlier than would otherwise be possible; he therefore sees no reason why the drug should not always be used in the operation with this object in view.

Owing to the effect of the drug on the cornea in producing drying of the epithelium, it is essential not to use it too long a period before an operation, and, when it is instilled, that the lids be kept closed until the moment of beginning the same.

5. *In operations upon the ear, nose, and throat*, cocaine is of great value as a local anæsthetic. It is also of use as a means to render diagnosis of the condition of these parts easier and more certain.

In aural work, according to Dr. B. Alex. Randall, brucine excels cocaine as an anæsthetic, and morphine and atropine as analgesics. In nasal cases the drug is of extreme value both in the study and the treatment of abnormal conditions. Dr. J. Solis Cohen and Dr. Carl Seiler both speak in the highest terms of its use as an anæsthetic in operative procedures upon the nasal chambers.

For the purpose of rendering the exploration of the larynx easy, the excision or scarification of the tonsils painless, and to permit the painless removal of pharyngeal neoplasms, elongated uvulæ, etc., cocaine is the anæsthetic indicated.

Major operations performed under cocaine anæsthesia can never meet with much professional favor,

for the patient, being conscious, endures a mental shock equal to, if not greater than, the physical one caused by the operation. Again, in all such cases, large and repeated doses of cocaine have to be injected, and the danger of producing poisoning is great.

Dangers and Accidents attending the Use of Cocaine.—In the personal experience of the authors, no untoward results have occurred in cases treated with cocaine for anæsthetic purposes; but deaths have been reported from its similar employment. Among the principal after-effects described as following its use are persistent nausea, headache, sleeplessness, anorexia, derangement of digestion, great mental depression, a sensation of suffocation, præcordial pain, vertigo, and muscular weakness sometimes amounting to incoördination. The mucous membrane of the urinary tract seems especially prone to give rise to annoying or even fatal results after the use of cocaine.

The treatment of these results must be based on general principles. Cocaine has no distinct antidote. There exists, however, a marked antagonism between this drug and morphine, also between cocaine and chloroform or ether. Nitrite of amyl is recommended as an antidote in cases of poisoning.

CHAPTER IX.

MINOR LOCAL ANÆSTHETIC SUBSTANCES.

Alcohol has been employed to produce local anæsthesia. It possesses the property of removing sensibility to pain, while not interfering with tactile sense (Buxton). The alcohol is cooled to ten degrees or so below the freezing-point by placing it in ice and salt, and the part to be numbed is then placed in it. For practical purposes, however, such a use of alcohol will hardly be found available.

Carbolic Acid when applied to the skin, though at first causing irritation and pain, soon produces a complete suspension of sensibility. If it is desired to benumb a part with this agent before making an incision, the acid may be painted over the skin, but its effect does not penetrate deeply, and the damage caused by the caustic action of the acid upon the tissue renders its application justifiable only in cases where a better remedy is unobtainable.

Carbon Disulphide has been occasionally used for the purpose of producing local anæsthesia. Its action is prompt and energetic. If used with a spray it causes congelation of the watery vapor associated with the jet. The frost thus formed liberates so much latent heat that congelation of the tissues is prevented, but they become insensible, notwithstanding (Lyman). The disadvantages of this compound are its disgust-

ing odor, and its poisonous qualities if inhaled in any quantity.

Drumine, an alleged anæsthetic alkaloid derived from the *Euphorbia Drummondii*, has been shown to be neither an alkaloid nor an anæsthetic. It seems to be a compound made up in great part of oxalate of lime.

Erythrophline is obtained from the bark of the *Erythrophleum guineense* or *Judiciale*, or "red-water tree," a native of the west of Africa. An infusion of the bark is used in that region to poison arrow-heads, and for the purposes of ordeal in the trial of accused persons. Lewin, of Berlin, has found that erythrophline exerts an anæsthetic effect upon the conjunctiva similar to that of cocaine, though this result is produced much more slowly, lasts much longer, and causes some temporary irritation of the conjunctiva. A two-per-cent. solution of the hydrochlorate caused the pupil to contract, and occasioned a loss of feeling in the eye lasting from ten to twenty-four hours; the irritation induced by the drug was considerable. Dr. Lewin had an extremely painful cut of a finger, produced by a piece of glass. A few drops of the above solution caused the pain to cease in ten minutes. Applied to the tongue, it caused a most peculiar numbness.

It has been asserted that whatever anæsthetic virtue is possessed by this drug it has in common with the drugs which act as styptics and caustics, such as perchloride of iron.

According to some authorities, the after-effects of erythrophline are very disagreeable, the principal one being violent pain, coming on a few moments after its application and lasting some days.

The value of erythrophline as an anæsthetic must be determined by further study of its effects, coupled with a careful consideration of its poisonous character.

Ether Spray.—The rapid evaporation of highly-rectified ether has been taken advantage of by Dr. B. W. Richardson, and others, in the production of cold sufficient to freeze a part and thus render it temporarily insensible. A fine spray of ether is impinged, by means of a hand atomizer, upon the part to be anæsthetized. The skin rapidly becomes white and hard,—is, in fact, frozen. This method of inducing local insensibility to pain for the purpose of performing minor operations is sometimes efficacious. Care must be exercised that the freezing process be not carried too far, as otherwise a slough will be apt to ensue.

The Frigorific Mixture recommended by Mr. J. Arnott, of London, consists of two parts of ice and one part of salt. These materials are to be thoroughly pulverized separately, after which they are quickly mixed. The mixture is then put into a muslin or gauze bag, and as soon as it begins to melt—in a minute or so—it is to be placed on the part to be anæsthetized. As soon as the skin becomes white, opaque, and hard, anæsthesia is produced, and such minor operations as paracentesis, the opening of abscesses,

hypodermatic injections, etc., may be done without pain being experienced. The frozen part speedily recovers, no inconvenience resulting.

Gleditschine was at first supposed to be an alkaloid obtained from the leaves of the *Acacia stenocarpa*, but further research has shown that *Gleditschia triacanthus* is the true source. Its asserted anæsthetic properties were experimented with by Claiborne, Knapp, Jackson, of this city, and other investigators. The similarity of its effects to those produced by cocaine was noted, and Dr. John Marshall, of the University of Pennsylvania, discovered that the substance consisted of a mixture of cocaine and atropine, with a sufficient quantity of salicylic acid to prevent fermentation.

Rhigolene, one of the products of the distillation of petroleum, is another agent used to produce local insensibility, and was proposed for this purpose by Dr. Henry J. Bigelow, of Boston, in 1846. This is probably the most volatile liquid in existence. It is highly inflammable, boiling at 70° F., and consequently should be kept in a cool place and handled with due care. This substance is used to produce artificial anæsthesia in the same manner as ether,—from a spray bottle. One or two minutes suffice for freezing the tissues. Dr. Willard has used this article in some of the operations of minor surgery with success, but not with entire satisfaction. Its chief use is in cases of minor surgery where inhalations are inadvisable.

CHAPTER X.

SPECIAL MODES OF PRODUCING ARTIFICIAL ANÆSTHESIA.

Anæsthesia by Rapid Breathing, as suggested by Dr. W. G. A. Bonwill and Dr. Addinell Hewson, for the production of insensibility sufficient for the painless performance of minor surgical operations, has not been made use of to any extent by the general profession, mainly owing to the easier and more certain methods of inducing anæsthesia at our command. The *rationale* of this method of producing anæsthesia is supposed to be the accumulation of blood in the veins, and a consequent overcharging of the vessels of the brain with imperfectly oxygenated blood.

Anæsthesia by Electricity.—In 1857, an American dentist, Dr J. B. Francis, attempted to annul the pain of extracting teeth by passing an electrical shock through the tooth at the instant of its attempted removal. This method has justly fallen into disuse. The attempt to produce local insensibility in surgical operations by connecting the knife with one of the electrodes of an electrical apparatus has met with the same fate.

Anæsthesia induced by Hypnotism.—The term hypnotism, or mesmerism, denotes a transitory abnormal mental condition which can be produced experimentally in many persons. This state is characterized

mainly by an interference with, or an entire suspension of, the free will and judgment of the person acted upon, combined with a willingness to obey any suggestion, however unreasonable, of the hypnotizer. Almost every magnetizer has his special method of inducing this condition. According to Bernheim, the nature of the external means resorted to in producing the hypnotic state is of little importance, so long as it impresses the imagination of the subject hypnotized and conveys to him the idea that he will go to sleep.

The efficacy of "animal magnetism" as a means of inducing the so-called mesmeric trance or sleep was discovered by Anthony Mesmer, rather more than a century ago. It was, however, first studied in a scientific manner by James Braid, of Manchester, in 1843.

Since the time of Braid, until quite recently, few systematic efforts have been made to utilize hypnotism as a therapeutic agent.

Not only has the question of its employment for the purpose of producing surgical anæsthesia been discussed, but the method has been tried with success, both in surgery and in obstetrics.

If its use depended solely upon its power to alleviate the pain of child-bearing and of surgical procedures, hypnotism as an anæsthetic would no doubt rank as equal or even superior to ether and chloroform. Unfortunately, its practical application is attended with more or less danger,—as yet but

little understood. It is possible that in time these untoward results may be overcome, but at present we deem the experimental laboratory, rather than the operating-room and the lying-in chamber, the proper field for investigating its practical uses and dangerous qualities.

Anæsthesia by Intravenous Injection was suggested in 1872 by Dr. Oré, of Bordeaux. He recommended the use of chloral by this method as a means of producing artificial anæsthesia. He used a canula and syringe, which was to be introduced into a superficial vein and the chloral hydrate in solution then slowly injected. After a lapse of time varying from a few minutes to half an hour or over, the patient became completely insensible.

In fifty-three reported cases, the shortest period of anæsthesia thus produced lasted ten minutes; the longest was three hours. Several deaths occurred. The method is not to be advised for practical purposes.

Etherization by the Rectum is a method not to be advised. See Chapter III., p 36.

CHAPTER XI.

ARTIFICIAL ANÆSTHESIA IN OBSTETRICAL PRACTICE.

In view of the successful employment of ether in surgical practice, it is not surprising that the idea was conceived of annulling the pain of childbirth by its aid. The first administration of ether during labor was made by Sir James Y. Simpson, January 19, 1847. About one month later, he published a paper giving the result of his experience with this drug in natural confinement, and setting forth the important fact that the pain of parturition could by its employment be moderated or annulled without interfering with uterine contraction or expulsive effort.

In November, 1847, the substitution of chloroform for ether, as proposed by Dr. Simpson, gave a fresh impulse to the employment of anæsthetics in obstetrics; but their use in this direction did not achieve anything like the rapid triumph of surgical anæsthesia. A certain amount of opposition to the practice of administering anæsthetics for the pains of labor arose on the ground that the pain of childbirth was a physiological accompaniment of a natural process ordained by Providence, and that, as such, there could be no real advantage in its abolition. Other arguments as ridiculous as this were advanced in opposition to the procedure, but the benefits were so

apparent, and injurious consequences either to mother or to child were so entirely lacking, that the practice steadily gained ground, until now very few, if any, objectors are to be found to the use of obstetrical anæsthesia. In fact, the mitigation of the pains of natural labor by anæsthetics is considered not only entirely justifiable, but even a duty which the accoucheur owes to a patient who demands it, provided no positive contra-indication exists.

We do not deem it essential for obstetricians to make it an invariable rule to administer an anæsthetic in every case of natural labor, but we do think that wherever painful and harassing complications arise which prostrate the patient and protract labor, an anæsthetic is plainly indicated. Among the complications which call for the use of these drugs may be mentioned an unusually firm or resisting perineum, muscular spasm, œdema, a relatively large fœtal head or a relatively small pelvis, a vaginal cicatrix, a vesical calculus, a rigid os uteri, or an unusually sensitive nervous system ill calculated to bear pain. In such instances an anæsthetic will not only shorten labor, but will prevent undue shock which would lead to profound prostration. It seems to us, therefore, that anæsthetics should be employed in many of those states of labor in which painful resistance to expulsion is encountered, or in which pain is unusually severe.

In unnatural labor—that is, a parturition which,

if left undisturbed, would not terminate favorably either to the mother or child—the propriety of resorting to these agents cannot be disputed. We include in this class all cases of instrumental labor in which excessive pain is experienced; cases where version or craniotomy is called for; those in which there is adherent placenta; and cases complicated by certain forms of puerperal convulsions, etc.

In the management of *placenta prævia*, when the patient is seen early, before any great shock has been produced by excessive loss of blood, and with the os uteri dilatable, the indication would be to turn and deliver at once. An anæsthetic in such a case is invaluable (Fordyce Barker.)

Having settled the question as to the propriety of producing anæsthesia in a given case, the next point for consideration is, naturally, the

CHOICE OF AN ANÆSTHETIC, AND THE PROPER TIME FOR ITS ADMINISTRATION.

Relative to the choice of an anæsthetic agent we have two principal drugs to deal with,*—ether and chloroform. The former drug is the more stimulating, but it is bulky, inflammable, and not infrequently irritating to the lungs; while chloroform is sedative, more agreeable to the taste, more concentrated and powerful, and requires a smaller amount to produce a

* Mention of other substances here is necessarily excluded for want of space.

given result. For these reasons, chloroform is justly considered to be the agent *par excellence* in producing obstetrical anæsthesia. This is true, however, only of its use as an anodyne (Lyman). When complete anæsthesia is required for the graver operations of midwifery, ether should be employed.

The admixture of these drugs has been recommended as suiting certain constitutions better. Dr. D. M. Barr, of this city,* recommends, and has used in his own practice with considerable success, a mixture of *ether, three parts; chloroform, one part; and alcohol, two parts.* He claims for its use perfect immunity from suffering on the part of the patient, without intoxication, without vomiting, and without reaction or dangerous sequences.

Dr. Willard, in commenting upon this paper at the meeting of the Obstetrical Society of Philadelphia, before which it was first read, said "the secret of Dr. Barr's success in escaping the unfortunate results which so frequently occur was, undoubtedly, due to the fact he had acquired a facility in administration which enabled him to keep his patients just at that blissful point which exists in the early stage of anæsthesia, in which pain is obtunded and yet consciousness is exalted. He had frequently seen this condition of joyous hallucination in chloroform anæsthesia for surgical purposes, and it was a stage in which

*Anæsthesia in Labor; Medical and Surgical Reporter, March 13, 1880.

minor operations could be performed without pain to the patient. The alcoholic fumes from Dr. Barr's mixture would assist the chloroform in producing such a condition, and the dangers would certainly be far less than if profound sleep were induced." Possibly an individual method of hypnotism.

In reference to the time at which the anæsthetic should be given, chloroform, as a rule, should not be administered during the first stage of labor, partly because of its tendency, when given at too early a period, to weaken the contractions of the uterus, and partly because protracted anæsthesia has a tendency to impair the cardiac force (Lusk). There are, however, numerous exceptions,—as, for instance, when patients suffer more severely during the first stage than during the second. In point of fact, the time for the use of these agents will depend largely upon the individual study of each case, remembering that the object desired is the alleviation of pain by *anæsthesia*, and not the production of *narcosis* through a determination to *abolish* pain altogether. According to Lyman, the unfavorable results which have been ascribed to anæsthesia during an early period of labor have been due altogether to an *excessive* use of the anæsthetic.

Snow advised that chloroform should be withheld until the os uteri was fully dilated and well-marked expulsive pains had appeared. He made an exception to this rule when during an earlier stage the pains were very severe.

Method of Administering Anæsthetics in Obstetrical Practice.—In the major operations of obstetrical work, when profound anæsthesia (narcosis) is required, ether, as previously stated, should be employed, and its administration is to be conducted on the general principles observed in its employment for other surgical purposes. In normal labor, chloroform is the anæsthetic generally used, and the mode of its administration for this purpose differs materially from that employed for surgical anæsthesia. While the one is a continuous state of partial anæsthesia, in which the influence of the agent is slight and readily passes off, the other is a regular progressive process carried steadily to a definite point, the patient being so deeply narcotized that a return to consciousness of suffering requires considerable time. The open method of exhibition is the best. At the beginning of each pain the patient should be directed to take a number of deep inspirations, the anæsthetic being kept at a little distance from the mouth. By this means, according to Dr. W. T. Lusk, the patient is prevented from inhaling an undue amount of the anæsthetic during the expiratory efforts which are put forth in the acme of the pain.

The chloroform should be used in small quantities at a time,—the additions being made drop by drop. Continual attention should be paid to the general state of the patient during the use of the drug, remembering that success in the management of

obstetrical anæsthesia requires the most scrupulous care and incessant watchfulness, as well as considerable skill, upon the part of the anæsthetizer.

The objections to the use of an anœsthetic in labor, though strenuously urged by some authorities, are probably theoretical rather than real. As enumerated by Dr. Dudley Buxton (*op. cit.*), they are as follows:

1. *It is said to increase the mortality alike among mothers and children.*

Experience fails to confirm this statement. As chloroform minimizes the pain of labor and consequently the shock thereby produced, it is rational to assume, and observation sustains the assumption, that the danger to the parturient is proportionately lessened.

Protracted complete anæsthesia would, however, affect the blood-aëration of both mother and child; and the danger of post-partum hemorrhage would be more imminent.

2. *It is asserted that it protracts labor.*

Here, again, experience is contradictory to the objection. It is only when chloroform is pushed to the degree of deep narcosis that uterine contractions are interfered with and labor protracted.

3. *Rupture of the perineum is said to follow more commonly when chloroform is used.*

If the same care be exercised in the treatment of labor cases with the use of an anæsthetic as is exercised where no such agent is employed, there can be

no special reason for ascribing this accident, if it does occur, to chloroform. On the contrary, the partial relaxation of the parts, induced by the anæsthesia of the patient, should tend to obviate rather than produce this complication.

4. *Complications are asserted to be more liable to occur when chloroform is used.*

Upon this point Dr. Buxton quotes the opinion of the Chloroform Committee of the Royal Medico-Chirurgical Society, who thoroughly investigated the subject. They found that when chloroform is properly administered it does not predispose to inflammation, puerperal convulsions, apoplexy, or other mishaps; indeed, as it promotes dilatation of the maternal passages, it is beneficial.

Convalescence is not retarded by its use (Sansom); lactation is not injuriously affected, nor is the child in any way injured (Buxton).

The relative safety of chloroform in parturition ceases with the birth of the child. After delivery it is said to favor the relaxation of the uterus and to predispose to hemorrhage (Lusk). Therefore upon the birth of the infant the anæsthetic should be withdrawn, unless some slight surgical operation should require its continuance, such as placing a stitch in a lacerated perineum.

Childbirth is justly deemed the least dangerous occasion for the employment of anæsthesia. This is not due to any special immunity possessed by par-

turient women, but, according to Dr. Henry M. Lyman, is in all probability owing to the fact that such women are selected patients, as it were,—in the prime of life, at an epoch when all the nutritive functions of the body are at their highest degree of activity,—and therefore necessarily present the best possible cases for withstanding the risks involved by the production of anæsthesia. Furthermore, the partial degree of anæsthesia, to which alone the greater number of pregnant women at times are subjected, is far less dangerous than the condition of absolute anæsthesia required in most cases of surgical operation.

CHAPTER XII.

MEDICO-LEGAL RELATIONS OF ARTIFICIAL ANÆSTHESIA.

The consideration of the medico-legal aspects of the administration of anæsthetics involves many points of interest and importance to the administrator of these drugs, as well as to the profession in general. It is impossible, in the space allotted to this subject, to enter into a full discussion or even to give a complete list of all the questions of a medico-legal nature to which the introduction of artificial anæsthesia has given rise. We shall therefore content ourselves with a somewhat cursory consideration of the principal issues involved, referring our readers, for a more extended account, to the special treatises relating thereto.

The question of medical responsibility for the fatal results of anæsthesia occurring during the ordinary course of medical and surgical practice will naturally first occupy our attention.

The anæsthetist, like any other medical man, is liable to prosecution for mal-practice; it then becomes his duty to prove that whatever course he pursued was followed only after due consideration and because he deemed it to be for the benefit of the patient.

We know that the physiological action of anæsthetics in producing anæsthesia is by a process peculiarly antagonistic to the ordinary forces of life

upon which all vital action depends. Consequently all anæsthetics used to induce anæsthesia act as poisons to the vital processes, and, when exhibited in sufficient quantity for a sufficient length of time, any one of them would inevitably destroy life. This, however, does not preclude their use, for the same is true of many substances employed in medical and surgical practice. Furthermore, experience shows that these agents differ in the degree of their energy and in their tendency to produce dangerous results: therefore the medico-legal question might arise, did the anæsthetist employ the most suitable agent according to his view of the exigencies of the individual case?

If, having employed an anæsthetic that is duly accredited by competent authority to be the remedy *par excellence* in a given case, death or serious accident follow its use, the surgeon may still be called upon to answer such questions as the following: Did he administer the anæsthetic with due care and after the most approved method? Did he undertake a duty which knowledge, skill, and experience had qualified him to fulfil? Was it a case in which no contra-indications to anæsthesia could be discovered? Or was the induction of insensibility warranted by the gravity of the case? If these inquiries can be answered in the affirmative, and no other negligence on the part of the administrator be proved, he cannot be held responsible for any fatality that may ensue from the administration of an anæsthetic.

From this it will be seen that though there may have been no criminal intention on the part of the surgeon to cause the death of his patient, yet this fact alone will not suffice to save him from judicial censure or from a liability to a suit for damage. In order to exonerate himself entirely from such proceedings he must be able to show clearly that there was on his part no imprudence, no carelessness, no lack of attention, nor any failure to observe all the rules of procedure in such emergencies as may arise even from the most cautious administration of these agents.

An anæsthetic should not be administered to a person against his will, except for pressing necessity. If the patient is a minor, the consent of the parent should, if possible, be obtained, lest such a proceeding constitute an assault. If, however, a patient voluntarily submits to be anæsthetized, and under the influence of terror during the early stage of the administration of the agent attempts to prevent further narcosis, the anæsthetizer is bound to exercise his own judgment and to proceed as he thinks best for his patient's interest, the patient not being deemed sufficiently under control of his reason.

Anæsthetics have been employed to assist in the perpetration of various crimes upon the persons narcotized. Thus, an anæsthetic may be given, it is alleged, without the consent of a person; or when given with the patient's consent to effect a lawful purpose, advantage may be taken of the unconscious and helpless condition of the patient to perpetrate a crime.

Can an anæsthetic be administered without the consent of the person to be anæsthetized?

We will first consider this question in relation to *persons awake and in full possession of their senses.* The subject of the possibility of inducing anæsthesia for criminal purposes upon persons in this condition has been extensively discussed. When the use of anæsthetics was first introduced, much alarm was experienced lest the new agents should be employed to facilitate the commission of robbery or of rape. Formerly, many cases came into the law courts in which it was alleged that the complainant had been overpowered by an inspiration of chloroform, causing immediate insensibility. But we now know that this is impossible, and that anæsthesia cannot be induced upon a person awake without obtaining consent, or without such an exhibition of constraining force as would render its induction unnecessary.

Is such the case with a person sleeping naturally? Can such an individual be narcotized sufficiently to produce anæsthesia, without being awakened?

According to Dr. H. C. Wood, such a procedure is possible. He cites experiments made at the Philadelphia Hospital, and confirmed by M. Dolbeau,* in which it was clearly proved that persons sound asleep may be chloroformed without being awakened; but adds that anæsthesia cannot be produced in any one

* Annales d'Hygiène, January, 1874.

partially awake, or even sleeping lightly, without his knowledge.

It must be borne in mind, however, that in the above instances the anæsthetic was administered by experts and in a scientific manner. Such is not the case when this drug is employed by criminals for the purposes of robbery, rape, etc.,—these individuals usually being novices. It therefore seems to us highly improbable that persons other than those entirely familiar with the administration of this agent,* its mode of action, and the dangers incurred in its employment, would succeed in such an attempt.

Furthermore, the risk of awakening the slumberer, or, if that does not occur, of adding the crime of murder to that of robbery, etc., together with the additional time required for the administration of chloroform, would be sufficient to prevent its use by novices for the purposes of crime. It may be an excess of charity to credit this class of criminals with any anxiety about their intended victims, as to whether they die or not; but a common-sense view of the matter, we think, indicates the absurdity of such a step as the administration of an anæsthetic for the purposes of wrong-doing, short of murder itself, that is surrounded with so much danger, with a strong

* Ether is not usually employed for criminal purposes, owing to its greater bulk, its more irritating nature, its more powerful odor, and its comparative slowness of action in producing insensibility, as compared with chloroform.

possibility of failure, when simpler means would accomplish the desired result.

Accusations of attempted rape under anæsthetics, when these agents have been used to effect a lawful purpose, have been frequently made by patients, who affirm that the dentist or surgeon has violated their persons while they were insensible. Not only have wicked, designing women made such charges, but modest, virtuous, and refined ladies have been prosecutors in these cases. The reputation of innocent medical men, socially and professionally, has been ruined by prosecution and conviction on the charge of alleged criminal assault under these circumstances, especially in the past, before physicians had learned that the presence of a third person was an absolute necessity.

Fortunately, the cause of this unfortunate and somewhat remarkable state of affairs is now understood. Chloroform, ether, nitrous oxide gas, and, according to Buxton, possibly also the other carbon compounds employed to induce anæsthesia, possess the property of exciting sexual emotions, and in many cases produce complete venereal orgasm. Nervous women, especially those suffering from ovarian or uterine affections, are prone to such hallucinations, and it is next to impossible to convince them that the sexual excitement is due to the influence of the anæsthetic and not the result of improper actions on the part of the anæsthetizer.

Granting that the vast majority of the accusations against doctors and dentists of criminal assault attempted during the induction of anæsthesia are false, for the reasons just given, we must not lose sight of the fact that anæsthetics may be and probably have been used to facilitate the violation of women. Therefore if the administrator of an anæsthetic wishes to insure himself from having such a charge preferred against him, it is absolutely necessary when the patient is a female, to have a third person present.

DEATH UNDER AN ANÆSTHETIC.

The inquiry into a death supposed to have been caused by an anæsthetic begins with the question, was it due to the narcotic, or to hemorrhage, shock, or some cause attributable to surgical interference? When doubts arise as to the cause of death following the use of an anæsthetic, and a judicial investigation is begun, recourse must be had to toxicological analysis. The possibility of a coincidence of other causes of death must be excluded by the results of an autopsy; in fact, no decision regarding the cause of death during anæsthesia should be announced without a careful post-mortem examination of the entire body. Let us, therefore, briefly consider the question of death from ether, from chloroform, and from nitrous oxide gas, principally in relation to the post-mortem appearances produced, and to the detection of these substances by analysis.

POISONING BY ETHER.

Symptoms.—Swallowed in large doses, ether produces very nearly the same effects as a large amount of alcohol. There is usually a short period of delirious excitement, which is followed by coma and other symptoms of narcotism, similar to those caused by alcohol. Ether is a more powerful local irritant than alcohol. Orfila ("Toxicologie," tome ii., p. 531), in his experiments upon dogs, found the mucous membrane of the stomach and duodenum violently inflamed by a lethal dose of ether. The heart contained black blood, partly coagulated. The lungs were gorged with fluid blood.

Ether when swallowed has not caused death in the human subject (Taylor).

The post-mortem appearances present nothing peculiar, except a very perceptible ethereal odor, which is scarcely ever absent, and is known to persist for some time after death.

Chemical Analysis.—Ether is recognized by its taste and smell; by its combustion; by its volatility; and by its action on a piece of asbestos moistened with a mixture of sulphuric acid and bichromate of potassium, the asbestos being turned green.

POISONING BY CHLOROFORM.

Poisoning by chloroform may occur through inhaling the vapor or by drinking the fluid. The effects of chloroform when taken internally, according

to Dr. J. J. Reese, are those of a local irritant to the stomach, together with those of a powerful narcotic, causing speedy insensibility, stupor, convulsions, dilated pupils, flushed face, a full and oppressed pulse, and foaming at the mouth. Some cases have been reported in which the pupil was contracted. Fatal results have followed the swallowing of chloroform.

The post-mortem appearances in those who die comatose from chloroform do not afford a single characteristic or pathognomonic sign. Whatever lesions may have been set down as characteristic in the past, we now know are to be met with in many other forms of death. According to Dr. J. J. Reese, in death from *liquid* chloroform the characteristic odor will usually be apparent, together with a slow putrefaction of the body and persistent rigor mortis In several fatal cases reported, there was evidence of great irritation of the lining membrane of the stomach, proceeding to actual softening, and in one case to ulceration. In cases of death resulting from chloroform vapor, Dr. Reese states the most common lesions to be great congestion of the lungs and bronchial tubes, and a dark and fluid condition of the blood. Sometimes there is congestion of the vessels of the brain.

Chemical Analysis. — According to Dr. Dudley Buxton, the substance supposed to contain chloroform is placed in a flask, one end of which is immersed in a hot-water bath, the other end communi-

cating with a small tube which is heated by a flame. The bath is raised to 160° F., while the tube is heated to redness. Chloroform vapor driven off by the heat of the water-bath is split up as it traverses the tube, chlorine and hydrochloric acid being set free. The vapor reddens litmus, precipitates solutions of nitrate of silver, and liberates iodine from iodide of potassium, which latter is tested for in the usual way with starch paper.

POISONING BY NITROUS OXIDE GAS.

The large number of minor operations performed at the present time with the aid of this gas, such as the extraction of teeth, opening of abscesses, etc., with but few accidents, would seem to show that there is comparatively little danger in it when administered by a competent anæsthetizer; yet if the effect should be prolonged we believe that danger would ensue. The few fatal cases which have been recorded, either during or after the narcosis, show that it is not absolutely devoid of danger. This danger, according to Dr. Buxton, is increased if the patient is allowed to feel pain, especially in operations upon the fifth pair of nerves; but little risk is run when the gas is given fully and the operator desists from its use before consciousness returns.

The autopsy reveals no special lesion, the body showing simply signs of death from syncope or from asphyxia.

INSANITY FOLLOWING THE ADMINISTRATION OF ANÆSTHETICS.

Among individuals predisposed to insanity the administration of anæsthetics may in certain cases determine an attack of mania.

Dr. Geo. H. Savage, Superintendent of the Bethlehem Royal Hospital, London, has called the attention of the profession to this subject in a paper read at a meeting of the British Medical Association, held in Dublin, August, 1877.* His experience proves that any anæsthetic substance is capable of so interfering with cerebration, in those cases where the person is either highly neurotic or comes from a family in which insanity has developed, that a mania, persistent or transient, may be induced. It is well, especially from a medico-legal point of view, to keep this fact in mind.

Self-indulgence in the use of anæsthetics is a practice by no means uncommon.

The *habitués* of such unhappy practices as the self-administration of chloroform, of ether, of cocaine, etc., are frequently encountered. As death may follow such a use of these remedies, the medico-legal inquiry may arise, was the case one of suicide, or one of murder following the employment of the anæsthetic? It is therefore important that the medical expert, in

*British Medical Association Journal, December, 1877.

giving testimony, should bear this point in mind, and should see that the line of inquiry in a doubtful case is directed towards the habits of the individual.